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Pediatric Radiology

Evaluating current chest imaging practices of pediatric patients with COVID-19: A retrospective analysis[☆]Vincent R. Li^{a,b,*}, Amit Sura^{a,c}, Trevor Pickering^c^a Children's Hospital of Los Angeles, United States of America^b University of Southern California Dornsife College of Arts and Sciences, United States of America^c University of Southern California Keck School of Medicine, United States of America

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ABSTRACT

Purpose: This retrospective analysis aims to examine the effectiveness of the current chest imaging guidelines regarding COVID-19 positive pediatric patients on our study group of patients aged 0 to 18.**Materials and methods:** We examined clinical and imaging data of 178 pediatric COVID-19 positive patients confirmed by PCR admitted to the Children's Hospital of Los Angeles between March 6, 2020 and June 23, 2020.**Results:** Of 178 patients, only 46 (27%) patients underwent any form of chest imaging. Thirteen (28%) of 46 imaged patients had positive chest X-rays (CXR) or computed tomography (CT) chest findings, with 8 (62%) of the 13 patients suggesting pneumonia or multifocal pneumonia, 3 (23%) patients having acute respiratory distress syndrome, and 2 (15%) patients demonstrating left sided pleural effusions thought to be the result of ruptured appendicitis unrelated to their COVID-19 diagnosis. All but one patient had significant prior medical histories with an associated comorbid medical condition. Of the 46 imaged patients, 17 (37%) patients had a negative chest X-ray, and 15 (33%) patients had suggestive findings of viral etiology. 132 patients were not imaged.**Conclusion:** Our study population corroborated current chest imaging guidelines in pediatric patients. Chest imaging modalities such as CXR and CT should be reserved for patients who are severely symptomatic and/or possess prior comorbidities such as immunosuppression, diabetes, asthma, obesity, or where other differential etiologies must be entertained.

1. Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2, or COVID-19) has rapidly spread worldwide to become a global pandemic threatening the capacity of numerous national health care systems. At the time this manuscript is writing (April 2021), the confirmed COVID-19 cases, including children, have reached 30 million in the USA and 128 million globally and are continuing to rise.¹ Despite increased infection in children, COVID-19 seemed to have a limited impact on children, with only a small number of symptomatic and severe cases compared to the adult population.^{2–5} However, infected children are playing a similar role as infected adults are in ongoing disease transmission.^{3,6}

Imaging studies, in particular chest imaging in adults, play an important role in management of COVID-19 patients. Chest X-ray (CXR)

and/or chest computerized tomography (CT) of the chest can be useful tools in the investigation of respiratory tract infections from COVID-19 in adults.^{7,8} However, their use in children remains inconsistent⁸ or inconclusive.^{5,9–13} From published literature, CXR and CT chest imaging findings in pediatric patients are often indeterminate and have limited value in COVID-19 evaluations. The American College of Radiology has since recommended that imaging should be prioritized on hospitalized and severely symptomatic patients, or if they possess specific clinical indications where other disease processes other than COVID-19 must be considered.¹⁴

Based on the limited literature, an expert consensus statement on chest imaging in pediatric COVID-19 patient management was published recently.¹⁵ The recommendations for this consensus help address COVID-19 related uncertainty in CXR and CT chest imaging manifestations of COVID-19 in children by implementing a structured radiology

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reporting template, providing practical clinical guidance regarding effectiveness of chest imaging in patients. The purpose of this work is to examine whether the pediatric patients at our institution evaluated for COVID-19 followed similar practices in regard to previously established CXR and CT chest imaging guidelines already set forth.

2. Methods

Clinical and imaging data collected for 178 pediatric patients admitted to or seen in the emergency room at the Children's Hospital of Los Angeles (CHLA) between March 6, 2020 and June 23, 2020 were assessed. All patients were confirmed with COVID-19 based on positive polymerase chain reaction (PCR) tests. Among them, 56 were inpatients, 103 were emergency room patients, and 13 were scheduled to receive an operation. Fifty-one patients were diagnosed with COVID-19 after being assessed and diagnosed for unrelated illnesses aside from COVID-19. The demographics and admission diagnoses of these patients are provided in Table 1. Examples of the admission diagnoses for the 51 patients admitted due to COVID-19 unrelated issues are tabulated in Table 2. Notable imaging findings along with other medical data were analyzed.

3. Results

3.1. Patients and clinical findings

A review of the data collected indicates that 46 (26%) out of 178 patients had CXR or a CT of the chest while the remaining 132 (74%) patients had no imaging, in line with previously outlined recommendations of not performing any imaging for patients that demonstrate mild to moderate symptoms. Among the patients without imaging, 85 (64%) cases were admitted due to COVID-19 related symptoms, thought to be mild or moderate, while 47 (26%) cases came in for unrelated diagnostic purposes (Table 2). The total number of patients who came in for COVID-19 unrelated symptoms was 51, in which 3 patients had a negative CXR and one had a negative chest CT.

In the 46 cases where chest imaging was performed, 17 (37%) had a negative CXR; 15 (33%) had findings consistent with viral etiology, 13 (28%) had other positive CXR or CT chest imaging findings. Of the 13 patients, 8 cases had a CXR indicative of pneumonia or multifocal pneumonia. Of these 8 cases, one had a history of prior congenital heart disease status post Fontan procedure, 2 had a history of acute lymphoblastic leukemia (ALL), 2 patients had a history of obesity and asthma, one patient with just a history of just obesity, and one patient with type II diabetes. There were three patients with CXR findings compatible with acute respiratory distress syndrome, two patients possessing significant

Table 1

Demographics and admission diagnoses of 178 COVID-19 patients admitted to CHLA between March 6, 2020 and June 23, 2020.

	Patient number <i>n</i> (%)
Patient age (years)	
0–1	45 (25%)
1–4	31 (17%)
4–12	54 (30%)
12–18	48 (27%)
Gender	
Male	90 (51%)
Female	88 (49%)
Admission diagnosis	
Fever only	48 (27%)
Fever along with other symptoms	11 (6%)
COVID-19 exposure or tested positive	17 (10%)
Other COVID-19 related symptoms (headache, cough, diarrhea, pharyngitis, chest/abdominal pain, etc.)	51 (29%)
Unrelated diagnosis (detailed in Table 2)	51 (29%)

Table 2

Primary diagnoses for 51 patients who also tested positive for COVID-19.

Primary diagnosis	Patient number (%)
Fracture	3 (6%)
Skin abscess	3 (6%)
Urinary tract infection	2 (4%)
Soft tissue mass	2 (4%)
Testicular pain	2 (4%)
Sarcoma	2 (4%)
Abnormal gait	2 (4%)
Ovarian cyst	2 (4%)
Laceration	2 (4%)
Head trauma	2 (4%)
Inguinal hernia	1 (2%)
Otomastoiditis	1 (2%)
Cholelithiasis	1 (2%)
Intussusception	1 (2%)
Scoliosis	1 (2%)
Phimosis	1 (2%)
Foreign body ingestion	1 (2%)
Facial palsy	1 (2%)
Neck contusion	1 (2%)
Pancytopenia	1 (2%)
Ureteropelvic junction obstruction	1 (2%)
Multiple congenital anomaly	1 (2%)
Epilepsy	1 (2%)
Solitary kidney	1 (2%)
Internal abscess	1 (2%)
Fibroadenoma	1 (2%)
Central nervous system vasculitis	1 (2%)
Subdural empyema/meningitis	1 (2%)
Gallstones	1 (2%)
Mastoiditis	1 (2%)
Ventriculoperitoneal shunt malfunction	1 (2%)
Nasal septal deviation	1 (2%)
Sleep apnea	1 (2%)
Viral exanthem	1 (2%)
Gastro-jejunal tube misplacement	1 (2%)
Manual vacuum aspiration	1 (2%)
Exotropia	1 (2%)
Feeding issues	1 (2%)
Cleft palate	1 (2%)

past medical history, that of congenital heart disease the other with obesity and asthma.

Only two patients having pneumonia, multifocal pneumonia, or acute respiratory distress syndrome (ARDS) did not have a significant medical history. Two patients had a CT scan of abdomen and pelvis due to history of perforated appendicitis. The abdominal and pelvic CT for both patients demonstrated left sided pleural effusions, of which one patient had it drained. There was one case in which a CT of the abdomen and pelvis was obtained for assessment of ruptured appendicitis, and an incidental non-specific right lower lobe lung nodule was noted. For clarity, these data are presented as a case flowchart in Fig. 1. Major imaging findings along with their confidence interval (CI) are tabulated in Table 3.

3.2. Imaging findings

Presented below are examples of various imaging findings. Fig. 2

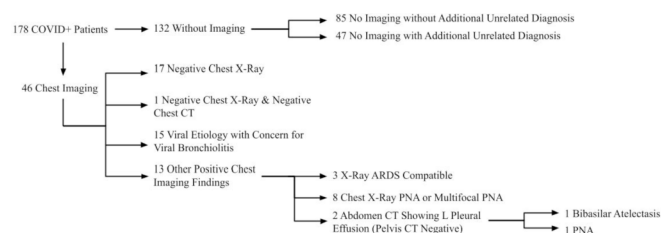


Fig. 1. Case flowchart showing number of cases for various imaging findings.

Table 3

Statistics of major imaging observations along with their percentage breakdown and 95% confidence intervals (CI).

Image study and observations	Case #/total cases	% & 95% CI
No imaging study	132/178	74.2% (67.1%, 80.4%)
No imaging study nor additional unrelated diagnosis	85/178	47.8% (40.2%, 55.4%)
No imaging study with unrelated diagnosis	47/178	26.4% (20.1%, 33.5%)
Chest imaging	46/178	25.8% (19.6%, 32.9%)
Negative CXR	17/46	37.0% (23.2%, 52.5%)
Viral Etiology	15/46	32.6% (19.5%, 48%)
Negative CXR & negative chest CT	1/46	2.2% (0.1%, 11.5%)
Positive CXR or CT	13/46	28.3% (16.0%, 43.5%)
CXR pneumonia or multifocal pneumonia	8/13	61.5% (31.6%, 86.1%)
XR ARDS compatible	3/13	23.1% (5.0%, 53.8%)
Abdomen and pelvis CT showing L pleural effusion	2/13	15.4% (1.9%, 45.4%)
Positive CXR or CT with history of obesity	4/13	30.7% (9.1%, 61.4%)

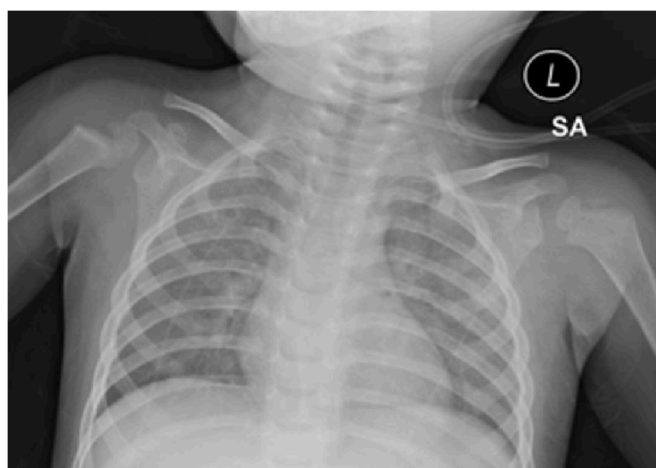


Fig. 2. Chest X-ray of a 14-month-old boy presenting to the emergency room with cough, reported by radiologist with an impression of viral etiology, findings consistent with viral bronchiolitis.

shows the CXR of a 14-month-old boy presenting to the emergency room with cough. The impression was consistent with viral bronchiolitis. **Fig. 3** presents CXR of a 14-year-old male transferred to CHLA pediatric ICU due to acute renal failure, obesity and asthma. Radiographic findings show both right and left lung opacities reported as multifocal pneumonia. **Fig. 4** shows CXR of a 16-year-old male with history of obesity, well controlled asthma, and prolonged symptoms of COVID-19 infection. Findings were reported as diffuse opacities throughout the lungs compatible with acute respiratory distress syndrome. **Fig. 5** displays an axial slice of a CT scan of the abdomen and pelvis of a 13-year-old male with perforated appendicitis with no upper respiratory infection symptoms, demonstrating an incidental non-specific right lower lobe lung nodule.

4. Discussion

A major portion of pediatric patients analyzed in this work did not



Fig. 3. Chest X-ray of a 14-year-old male transferred to CHLA pediatric ICU with acute renal failure, obesity and asthma. Radiographic findings show both right and left lung opacities reported as multifocal pneumonia.

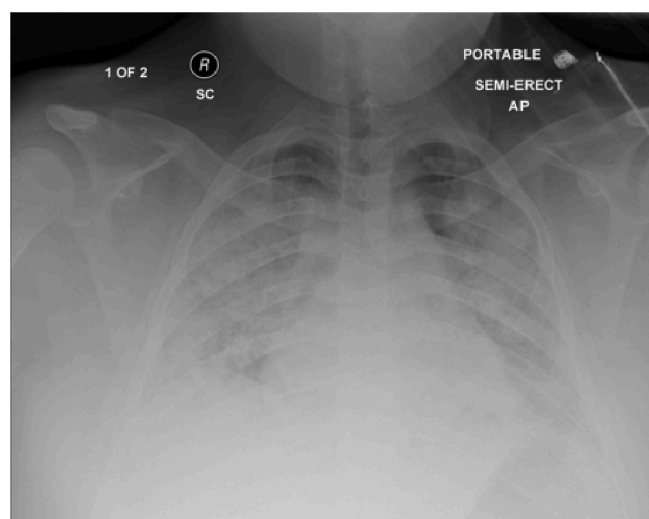


Fig. 4. Chest X-ray of a 16-year-old male with history of obesity, well controlled asthma, and prolonged symptoms of COVID-19 infection. Findings were reported as diffuse opacities throughout the lungs compatible with acute respiratory distress syndrome.

undergo imaging study given lack of any or if present, mild or moderate respiratory symptoms, in line with established current imaging guidelines. In patients where CXR were obtained, 28% (13/46) had significant findings while 33% (15/46) had findings compatible with a viral etiology. The rest were reported as negative. Of the 13 patients with significant findings, only one did not have a prior medical history that would place them in a category of having a comorbidity thus placing them at increased risk for severe disease from COVID-19. This is consistent with the well-documented connection between a patient's medical history and his/her affliction to COVID-19.^{16–18} It is uncommon to see definite imaging findings of COVID-19 on any imaging modality in pediatric patients, justifying the recommendation of avoiding prioritizing any imaging as a screening tool.

The majority of the patients who had significant CXR imaging findings were reported as having either pneumonia, multifocal pneumonia, or ARDS. One of the patients with ARDS is shown in **Fig. 4**. For such



Fig. 5. An axial slice of a CT scan of the abdomen of a 13-year-old male with perforated appendicitis with no upper respiratory infection symptom, demonstrating an incidental non-specific right lower lobe lung nodule (arrow).

patients who have severe symptoms, imaging is appropriate as part of their clinical management especially when considering other differential diagnoses.¹⁵ For patients with positive CT findings, images tend to show peripheral ground-glass opacities and/or consolidations but even such findings are non-specific, especially when comorbid conditions are at play. Even with initial severe imaging results, Shelmerdine et al. reported from a retrospective study that 60% of pediatric patients who had subsequent negative follow-up imaging with no significant imaging findings to report.¹⁰ Note that there were also 4 (31%) out of 13 patients with positive CXR or CT who had history of obesity.

The rest of the patients either had no irregularities during imaging or displayed CXR findings compatible with viral bronchiolitis, shown in Fig. 2 as an example. Although one patient with viral bronchiolitis required intubation, no other imaging was obtained as follow-up for this case.

There are at least two limitations in this study that must be considered. Firstly, the sample size for patients with imaging was relatively small. Consequently, descriptive, rather statistically significant, imaging findings are reported presently. Secondly, the data reported were collected within 6–10 months after their admission, thus no long-term follow-up was obtained. Despite these shortcomings, this analysis is meant to certify that current practices are efficient and remains informative for the management of pediatric COVID-19 patients.

5. Conclusion

This study concludes that chest X-rays should be reserved for pediatric COVID-19 patients who are severely symptomatic and/or are likely to have a comorbidity such as immunosuppression, diabetes, asthma and/or obesity. Chest CT should only be considered in a patient where there are severe symptoms of respiratory failure and an alternative diagnosis is considered. The current recommendations regarding imaging practices for pediatric COVID-19 patients outlined by the American

College of Radiology and issued by CHLA for pediatric COVID-19 patients are effective.

Declaration of competing interest

There are no notable disclosures to be declared by any of the authors.

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