Pediatric Coronavirus Disease 2019 and Radiographic Screening: Identification of Patients at Risk

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As the coronavirus disease 2019 (COVID-19) pandemic continues globally, there are an increasing number of pediatric cases. Since the initial symptoms of COVID-19 may overlap and co-exist with other respiratory infections typically affecting children, this review examines the use of computed tomography as a diagnostic and management tool. Children with preexisting conditions may be particularly prone to a more severe course. This study reviews and analytically summarizes the findings typically associated with severe acute respiratory syndrome coronavirus 2 in contrast with other more usual lower respiratory tract infections.

Keywords: COVID-19, pediatrics, computed tomography

Introduction

INFECTIONS CAUSED BY SEVERE acute respiratory syndrome coronavirus 2 (SARS CoV-2) are continuing to increase. Children may become infected by the single-stranded RNA virus, transmitted by contact with infected droplets spread from person to person. The identification of children who are healthy and those who have chronic illnesses is both a public-health issue and a local medical management challenge.¹ This paper focuses on the pediatric radiographic presentation of the disease. Certain hallmark features that present on high-resolution computed tomography (HRCT) images may heighten the recognition of coronavirus disease 2019 (COVID-19) among children. This report (1) summarizes and describes the typical HRCT findings associated with COVID-19, (2) contrasts the typical findings with those associated with non-COVID adult and pediatric viral pneumonia, and (3) highlights that the use of HRCT imaging supports the diagnosis, even in the absence of symptoms.

Methods

Literature search

A non-structured review of three primary sources was performed. The 3 sources included the search engines of Google, PubMed, and the Web site of the Radiological Society of North America (RSNA). The purpose of the search using the phrase “COVID-19, pediatric, child” was to identify cases of COVID-19 with available radiographic data.

Data analysis

Data were collected from 15 references and the RSNA Web site. The cases of patients who were <19 years of age were included for a descriptive analysis of their available (1) clinical presentation, (2) radiographic findings, and (3) progression of HRCT as available.

Literature Review

A non-structured review of articles obtained during the course of the review was also included to compare typical COVID-19 HRCT and clinical findings with typical findings of non-pediatric COVID-19 disease. Given the rapidly changing uncharted nature of the disease, the use of the same 3 major sources was used for consistency.

Clinical Features

Based on case studies and reports of patients who presented with COVID-19, certain key features help to identify children who may have COVID-19. Most patients will have a fever, including low-grade fever, and a dry cough, and as the disease progresses, shortness of breath may develop. Many healthy individuals may remain with few or no symptoms and serve as potential sources of the infection within their communities and during travel.¹

Gastrointestinal infection resulting in diarrhea is a finding among younger infants infected with coronavirus. The presence of congestion, nasal drainage, and a rash, which may be associated with other pediatric viral respiratory

illnesses, are typically not prominent but may occur. The quality of the cough is a dry hacking cough, which may trigger bronchospasm in some infants and children. Pediatric patients who have baseline lung disease may worsen and present with worsening symptoms of their underlying disease. Infants and children with coronavirus infection may also present with symptoms and signs of pneumonia, otitis media, and bronchiolitis.²

The physical findings of increased respiratory rate and shortness of breath without nasal congestion in particular may prompt screening testing for SARS CoV-2 by rapid diagnostic testing methods. The use of the chest radiograph and HRCT may be considered as part of the screening process.

Radiographic Features

Radiographic features reflect the underlying severity of disease and the progression of COVID-19. The rapid progression of the disease in affecting the lower airway is one distinguishing feature of SARS CoV-2 in comparison to less virulent strains of the same virus family (Middle Eastern Respiratory Syndrome and SARS CoV-1). If the presence of symptoms and signs consistent with COVID-19 are identified, the chest image may provide another important aspect of clinical assessment of the patient. In a large study of 1,099 patients, including 552 hospitalized patients with a median age of 47 years, 56.4% had ground glass opacities (GGO). The HRCT scan may be normal in 17.9% of cases and 2% of severe cases³). Based on a review of the variety of images online,⁴ 2 children were identified with consolidative changes on HRCT. One patient aged 10 years had no symptoms, and the HRCT findings began to resolve on day 4 of the illness. The other patient was a 17-year-old who presented with a low-grade fever (<101°F) and a cough. Both patients were in Wuhan, China, prior to the onset of their illness.

The temporal analysis of HRCT findings is used to follow patients during the illness and as new treatments are being tested in clinical trials. In studies describing the stages of COVID-19 disease, progression of lobular involvement and opacities from the onset until day 13 was observed prior to improvement. There were >50% of patients with GGO or consolidation. More than 80% of affected patients may show bilateral and multi-lobar involvement.⁵ In a study of 90 patients with 368 CT scans followed during the course of their COVID-19 infection, 2 radiologists scored the CT scans during the course of the illness. The findings indicate that CT abnormalities peaked on days 6–11 of illness. After symptoms developed, GGO were the predominant pattern, and 94% of patients discharged from the hospital had residual disease. Among these patients, GGO was the most common pattern. Prior to day 12, the abnormal patterns, which included sub-pleural distribution of opacification, were diverse, but subsequently GGO predominated.⁵

Contrast with Other Pediatric Viral Illness and Radiographic Findings

The combination of symptoms consistent with a lower respiratory infection may lead to the diagnosis of a non-SARS CoV-2 infection. The use of HRCT is an important adjunctive diagnostic and management study in supporting or ruling out the infection.

Influenza infection

Influenza viruses are members of the Orthomyxoviridae family. They are single-stranded RNA viruses that are associated with upper and lower respiratory tract infection. The viral infection is typically associated with similar symptoms, but the presence of nasal congestion and myalgias are more prominent during influenza infection. The HRCT findings reflect the initial cellular damage to the airway epithelium and involvement of the tracheobronchial airway tract. Children with influenza pneumonia often will demonstrate reticulonodular and focal areas of consolidation, particularly in the lower lobes.⁶ While reticulonodular densities have been noted in some cases of COVID-19, this finding is less commonly associated.

Bronchial wall thickening

Bronchial wall thickening is commonly associated with a number of lower respiratory pediatric illnesses but is not common in COVID-19. The presence of bronchial wall thickening is commonly associated with parainfluenza, influenza, respiratory syncytial virus (RSV), and human metapneumovirus (hMPV) infection, but not with rhinovirus, non-COVID-19 coronavirus, or herpes adult or pediatric viral disease.⁷

Centrilobular nodules

Other patterns that distinguish the known HRCT findings associated with COVID-19 from other lower respiratory tract disease include the finding of centrilobular nodules. Centrilobular nodules are more commonly associated with adenoviral, parainfluenza, RSV, and hMPV lower respiratory tract disease.⁸ Thus, bronchial wall thickening and a nodular pattern should prompt testing for non-COVID-19 pathogens.

Pattern recognition

Radiologists were able to distinguish COVID-19 lower respiratory tract infection from non-COVID-19 infection effectively in one study of 424 patients, including 219 COVID-19 patients with CT findings, based on blinded review.

There was variable but generally high accuracy in correct differentiation based on the review of 7 radiologists. There was a range of 67–93% in sensitivity and generally high specificity. The findings in this study reported that COVID-19 patients were less likely to have pleural effusion compared to non-COVID viral pneumonia patients (4.1% vs. 39%), less lymphadenopathy (2.7% vs. 10.2%), and less likely to have central airway involvement (14% vs. 35%).⁸ HRCT findings among the COVID-19 patients included peripheral distribution (80%), GGO (91%), fine reticular opacity (56%), and vascular thickening (59%).⁹

Other methods include artificial intelligence and deep learning in distinguishing community-acquired non-COVID infection from COVID-19 patients in a data set consisting of 3,322 patients. The overlap in findings on HRCT may be potentially addressed using this method, which yielded an area under the receiver operating characteristic curve of 0.96.¹⁰

HRCT and radiographic findings and test-positive cases

In the first case series from China, 151 cases of COVID-19 were described. The age range of children was 3–131 months, with a mean age of 74 months. Among the 10 children in this series, none presented with dyspnea. There were no CT findings described. Four patients had radiographic findings of patchy infiltrates, and among these cases, 2 did not have a cough. This case series demonstrates that among children who are test positive and have radiographic findings, clinical respiratory symptoms may be subtle or absent.¹¹ Based on review of available pediatric imaging data, an estimated 60% will demonstrate GGO and/or consolidation with or without halo sign.¹²

In another case series of 20 pediatric patients, 55% of the infected children were aged between 1 month and 3 years. Forty percent were co-infected (mycoplasma, influenza accounted for approximately one third of these cases). The authors summarized that 6/20 were unilateral pneumonia cases, 10/20 were bilateral, 4/20 had negative CT findings, and 12/20 had GGO. The presence of consolidation and halo sign was present among 50% of cases. Tiny nodules, while not a characteristic feature of coronavirus on HRCT, appeared in 3 patients. The presence of co-infection may further confound this finding. The symptom analysis of the children revealed that 65% had a cough, while only 10% demonstrated tachypnea.¹² The temporal development of early, advanced, critical, and recovery stages in HRCT progression are documented.

There was one case series of 2 test-positive children aged 4 years. Neither patient demonstrated dyspnea. The first patient had a cough and lung field opacifications (spots). The other patient had no symptoms and demonstrated bronchovascular bundles, which are unusual in described cases to date.¹³

Among 138 hospitalized patients described by Wang et al. ranging in age from 22 years to 92 years, younger patients all had bilateral patchy shadows or GGO on HRCT.¹⁴

Guan et al. reported 1,099 laboratory confirmed cases of SARS CoV-2. The presence of an abnormal HRCT was documented in 86.2% of the cohort, and 56.4% had GGO, while 51.5% demonstrated bilateral patchy opacifications. This study had only a small number ($n=9$) of patients <15 years of age.¹⁴

Children may also be exposed to family clusters of infection. In one report of 2 family clusters, a 15-year-old male with a fever of 100.2°F, and another 9-year-old male both tested positive without respiratory symptoms and had a negative thoracic HRCT. This report highlights the importance of transmission among family members, which may render children with chronic illness more vulnerable to developing illness.¹⁵

Chronic disease and co-infection

The presence of underlying disease and the possibility of secondary bacterial infection are areas of concern during the COVID-19 outbreak. The presence of secondary Streptococcal, Staphylococcal, and other viral agents may be expected to worsen and complicate the patient's course. The use of serial airway secretion cultures and polymerase chain reaction (PCR) to identify bacterial and viral co-infections

may be used in those with prolonged or severe illness.¹⁶ PCR can be falsely negative for a number of reasons, and there may be time lag in obtaining results.¹⁶ Chest radiographs are not always able to detect findings in children with COVID-19. In a series of 10 pediatric cases (aged 3–13 months, median 74 months) that only reported plain chest radiographic findings, 4 of the 10 children reported had radiographic findings of patchy infiltrates. None of the children had dyspnea, but all had a cough. The use of only plain chest radiographs may miss findings that are able to be detected by HRCT.¹¹

Conclusions

Testing by PCR using nasal swab samples is an important public-health measure in better understanding the disease. Management and screening using radiographic imaging in children who develop shortness of breath and respiratory distress allows serial comparisons and a measure of response to potential therapies. Plain chest radiographs are not reliable in detecting early changes in the lung. HRCT has more accuracy but may expose personnel to potential infection and the patient to radiation. Among some patients with no symptoms, the HRCT may be abnormal. The judicious use of HRCT may be helpful in following patients serially. Other clinical options include the bedside ultrasound imaging test. For patients who are symptomatic, with close COVID-19 contacts, the use of HRCT may be helpful in increasing suspicion for the disease.

Based on this report, HRCT findings are diverse and may be present with few or minimal symptoms. The drawback of this report is that there may be multiple other sources available on this topic not yet cited in PubMed searches, Google, or the RSNA Web site. The author acknowledges that other Internet postings may exist with additional cases. The recognition of HRCT patterns that are more consistent with other respiratory viral agents supports the use of molecular respiratory panel testing to determine whether there is a co-infection or another non-COVID-19 infection.

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References

1. Dong Y, Mo X, Hu Y, et al. Epidemiological characteristics of 2143 pediatric patients with 2019 coronavirus disease in China. *Pediatrics* 2020 Mar 18 [Epub ahead of print]; DOI: 10.1542/peds.2020-0702.
2. Cleri Dj, Ricketti AJ, Vernaloo JR. Severe acute respiratory syndrome (SARS). *Infect Dis Clin North Am* 2010; 24: 175–202.
3. Guan W, Zhong N, Hu Y, et al. Clinical characteristics of coronavirus disease 2019 in China. *New Engl J Med* 2020 Feb 28 [Epub ahead of print]; DOI: 10.1056/nejmMoA2002032.
4. Radiological Society of North America. RSNA Coronavirus cases. Available at <https://pubs.rsna.org/2019-nCovV#images> (accessed March 27, 2020).

5. Wang Y, Dong Ch, Hu Y, Li C, et al. Temporal changes of CT findings in 90 patients with COVID-19 pneumonia: a longitudinal study. *Radiology* 2020 Mar 19 [Epub ahead of print]; DOI: 10.1148/radiol.2020200843.
6. Agarwal PP, Cinti S, Kazerouni EA. Chest radiographics and CT findings in novel swine-origin influenza A virus infection. *AJR Am J Roentgenol* 2009; 193:1488–1493.
7. Kim MC, Kim MY, Lee HJ, et al. CT findings in viral lower respiratory tract infections caused by parainfluenza virus, influenza virus and RSV. *Medicine* 2016; 95:e4003.
8. Koo H, Lim S, Choe J, Choi S, et al. Radiographic and CT features of viral pneumonia. *Radiographics* 2018; 38:719–739.
9. Bai H, Hsieh B, Xiong Z, et al. Performance of radiologists in differentiating COVID-19 from viral pneumonia on chest CT. *Radiology* 2020 Mar 10 [Epub ahead of print]; DOI: 10.1148/radiol.2020200823.
10. Lin L, Qin L, Xu Z, et al. Artificial intelligence distinguishes COVID-19 from community acquired pneumonia on chest CT. *Radiology* 2020 Mar 19 [Epub ahead of print]; DOI: 10.1148/radiol.2020200905.
11. Jiehao C, Jing X, Daojiong L, et al. A case series of children with 2019 novel coronavirus infection: clinical and epidemiological features. *Clin Infect Dis* 2020 Feb 28 [Epub ahead of print]; DOI: 10.1093/cid/ciaa198.
12. Xia W, Shao J, Guo Y, et al. Clinical and CT features in pediatric patients with COVID-19 infection: different points from adults. *Pediatr Pulmonol* 2020 Mar 5 [Epub ahead of print]; DOI: 10.1002/ppul.24718.
13. Singhai T. A review of coronavirus disease-2019. *Ind J Pediatr* 2020; 87:281–286.
14. Wang D, Hu B, Zhu F, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA* 2020; 323:1061–1069.
15. Li-Na J, Chao S, Wang Y, et al. Clinical feature of pediatric patients with COVID-19: a report of two family cluster cases. *World J Pediatr* 2020 Mar 16 [Epub ahead of print]; DOI: 10.1007/s12519-020-00356-2.
16. Dong X, Cao Y, Lu C, et al. Eleven faces of coronavirus disease 2019. *Allergy* 2020 Mar 20 [Epub ahead of print]; DOI: 10.1111/all.14289.

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