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(REVIEW ARTICLE)

Imaging findings of COVID 19 in children: Literature review

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Abstract

Background: SARS-CoV-2 causes respiratory tract infections that can sometimes become severe, and the virus was first identified in Wuhan city, China, in late 2019. The term COVID-19 is used for clinical diseases caused by SARS-CoV-2. The number of cases and literature related to the radiological picture of COVID-19-induced pneumonia, its findings, and contribution to diagnosis, correlation with RT-PCR, and its differences with adults is still limited to pediatric patients.

Methods: We performed literature searches of the latest articles with PubMed, Google Scholar, and Cochrane Library databases published from 2016 to 2020 (5-year span). Two reviewers searched all articles independently (W and I., with more than five years of experience in radiology, respectively).

Results: A total of 35 papers was identified and screened for eligibility from medical databases. There were 24 papers and included in this review. In the population of children, manifestations in radiology are less noticeable. The diagnosis of COVID-19 should prioritize the usage of CXR. Radiology in COVID-19-induced pneumonia may differ between the population of children and adults. Patchy lesions are the most commonly found images on chest x-rays, while bilateral ground-glass opacities (GGO) are the most often features in CT scans. Peribronchial distribution and peribronchial cuffing were more commonly seen in pediatric patients but less frequently found in adults.

Conclusion: The characteristics of radiological features in pediatric patients with COVID-19 infection are patchy lesions, peribronchial distribution, and peribronchial cuffing.

Keywords: COVID-19; Pediatric; Pneumonia; Radiology imaging

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1. Introduction

A new coronavirus termed 2019-nCoV or SARS-CoV-2 leads to respiratory tract infections which sometimes may become severe. This virus was first detected in Wuhan, China, in late 2019 [1]. Then, it spread to other cities and internationally until causing a global pandemic on March 11, 2020. The term COVID-19 is applied for clinical diseases resulted from SARS-CoV-2 [2]. This virus is transmitted through exposure to respiratory droplets [3].

The clinical appearance of COVID-19 is relatively non-specific, like febrile, cough, myalgia, and fatigue. Its laboratory findings have also been shown to be relatively non-specific, although some researchers have reported lymphopenia, leukopenia, thrombocytopenia, increased C-reactive proteins (CRP), and elevated erythrocyte sedimentation rate (ESR). Therefore, thorax radiological examination, either chest X-ray (CXR) or computer tomography (CT) scan, plays a significant role in the COVID-19 diagnostic test. Besides that, delayed treatment may occur as a result of limited Reverse Transcription–Polymerase Chain Reaction (RT-PCR) tests to identify the SARS-CoV-2 virus despite its high false-negative rate. Thorax CT has proven to have a higher sensitivity level in identifying COVID-19 than early RT-PCR [4].

Most of the COVID-19 symptoms occurring in adult population are fever, cough, and malaise, which often need hospitalization [5]. Therefore, most of the published data are about therapy for adult patients with COVID-19 in various hospitals around the world. Currently, as the pandemic is still ongoing, many reports and data are showing the clinical manifestations and course of disease in pediatric patients confirmed with COVID-19 [2]. In the pediatric population, case reports and literature focusing on radiological features of COVID-19-induced pneumonia and its contribution to diagnosis as well as correlation with RT-PCR, and its difference from the adult's are still limited.

This literature review evaluates radiological findings observed in CXR and CT in children with the diagnosis of COVID-19 pneumonia.

2. Material and methods

We searched the latest articles in PubMed, Google Scholar, and Cochrane Library databases published from 2019 to 2020 using Boolean search strategies with the keywords: "Coronavirus," "COVID-19", "SARS-CoV-2", "pediatric," "radiology," "imaging," or "radiography." We retrieved additional articles by a manual screening of the included study reference list and relevant review articles. We conducted the initial search of the manuscript in October 2020, then assessed their eligibility, and finally analyzed the manuscripts meeting our inclusion criteria.

All articles were searched independently by three reviewers who have experience in radiology of more than 5 years. They examined the appropriate study abstracts and assessed the eligibility criteria of the full paper. The consensus was carried out to resolve any disagreements.

3. Results and discussion

3.1. COVID-19 Infection

China's Centers for Disease Control and Prevention reported 72,314 cases on February 11, 2020, in which only 2% of them were under the age of 19 [6]. A research published in early March 2020 showed that the pediatric population had the same likelihood as adults of being infected by SARS-CoV-2 virus, but were less likely to become symptomatic or developed into severe symptoms [7]. A case series with a sample of 34 children with COVID-19 found no children with underlying diseases. 65% had ordinary respiratory symptoms, 26% with mild illnesses, and 9% were without symptoms. The most dominant symptoms were fever (50%) and cough (38%) [8]. Most COVID-19 infected children were resolved and cured in one until two weeks after the symptoms occurred, and no mortality due to COVID-19 [9]. This shows that clinical symptoms are milder in children than in adults. Hypothesis currently reveals that children are less susceptible to COVID-19 due to resulted from angiotensin-converting enzyme 2 (ACE2) expression in the nasopharynx, which increases with age [10]. Although acute COVID-19 infection tends to be mild or asymptomatic in children, some of them were reported to experience Multisystem Inflammatory Syndrome in Children (MIS-C) a few weeks post-exposure to this virus. Patients with MIS-C experience severe heart complications, such as hypotension, shock, and acute heart failure [11].

A small case series showed no evidence that mothers can transmit SARS-CoV-2 vertically to infants [12]. Until now, most children infected by COVID-19 are part of the family cluster. A case series shows 100% of cases of babies infected with

COVID-19 have a family member experiencing symptoms before the baby is infected. As for children, 82% of them belong to family clusters [8].

The diagnosis of COVID-19 typically depends on clinical symptoms, contact history, and laboratory as well as radiological findings. CT scan findings are generally mild in pediatric patients; however, because of high radiation load, the exact role of chest CT scan imaging remains unclear [13].

This conducted study has shown that from 2,367 pediatric patients with COVID-19, 456 of them had no symptoms. The most typical symptoms include fever and cough. Some patients also complained of fatigue, abdominal pain, or loss of appetite. On the radiological examinations, 23.6% of patients showed no abnormalities, while computed tomography (CT) scan results obtained 18.9% of the findings were within normal limits. The patchy lesion was the most commonly found image on chest x-rays, while bilateral ground-glass opacity (GGO) was the most often feature in CT scans [14]. In the pediatric population, the manifestations in radiology were less noticeable. Most publications related to COVID-19 in children were based on CT scans, and most of them did not show abnormalities in early radiology assessments.

3.2. Chest X-Ray manifestations

Thorax X-ray is not required for most COVID-19 children with mild clinical symptoms and those who do not need hospitalization. However, thorax X-ray is commonly for neonates with febrile and respiratory febrile symptoms. In addition, CXR is suggested for pediatric patients with moderate to severe symptoms, clinical history, and underlying risk factors, which may require hospitalization and follow-up care. Positive signs in CXR may need hospital care or a repeated swab if the first PCR result is negative, as it increases suspicions of pneumonia [15]. Aside from that, it is essential to assess the evolution and response of treatment. Serrano et al. study (2020) reported that more extensive early involvement such as a combination of peribronchial cuffing, GGOS, consolidation, bilateral and diffuse resulted in a worse evolution. Therefore, immediate and intensive management of children is necessary [15].

CXR depends on parameters like normal or pathological, unilateral or bilateral, the number of lesions, lung zone, and other findings such as pleural effusion, lymphadenopathy, etc [16]. Wong et al. study (2020) revealed that 51 out of 64 subjects confirmed positive for COVID-19 showed abnormalities in CXR screening. They found consolidation in 30 (47%) patients and 21 (33%) patients. Regarding its distribution, lower zone distribution (32;50%) was more common than the peripheral ones (26;41%). Most of them had bilateral engagements (32;50%), while pleural effusion was seen in 2 cases (3%) [17].

Unlike adults, the most common findings in pediatric cases are peribronchial cuffing (86.3%) and GGOs (50%). An increase in density around the bronchial walls of the lungs defines peribronchial cuffing, and it is a non-specific bronchial response found at the onset of infectious and non-infectious diseases. Aside from that, peribronchial cuffing is often found in pneumonia resulted from other viruses, like H1N1 influenza, rhinovirus, respiratory syncytial virus, adenovirus, and other coronaviruses. In the study, 81.8% of CXR appeared bilateral perihilar peribronchial cuffing. Since it has low specificity, it is not regarded as a definitive sign of COVID-19 [15].

3.3. Chest CT manifestations

The data utilized in CT analysis and evaluation of every lesion comprise the affected lung side, either unilateral or bilateral, the numbers of lesions (single or multiple), affected lobe and lung segment, affected lung field (peripheral, central, or mix), lesion density as well as size, and other findings including major interstitium, major vascular structures within the lesion, halo sign, inverted halo sign, pleural effusion, and lymphadenopathy. The affected lung distribution is classified as upper, middle, and lower lobes of the right lung, the upper lobe of the left lung, the lingular segment of the left lung, the lower lobe of the left lung. The lung field distribution includes 1/3 of the outer area of the lungs, 2/3 of the inner lung area, and the mixture of both peripheral and central engagement. Pure GGO, GGO consolidation mixture, and pure consolidation evaluate lesion density [16].

A study in the adult population reported that thorax CT-scan has sensitivity, specificity, and accuracy of 97%, 25%, and 68%, respectively. During the early period, chest CT findings have a close correlation with clinical findings [18]. Kim et al. (2020) found that CT-scan had 94% sensitivity and 37% specificity. They also reported that the positive predictive value of RT-PCR was ten folds higher than that of CT imaging [19]. However, CT is not used to evaluate pneumonia evolution. It is for detecting and characterizing other complications. Radiological manifestations are less noticeable in the pediatric population. Most published studies on this population rely upon CT, and many of them did not demonstrate abnormal features in the early investigation. Based on CT examination results, 34% of the cases had no abnormal features despite positive COVID-19 [20].

Studies on CT thorax pneumonia COVID-19 findings in children are still limited. A meta-analysis demonstrated that GGO appearance is the most common finding in children, followed by patchy consolidation [21]. Other studies have also shown that multifocal peripheral GGO is the most common finding, beginning in the lower lobes, along with interlobular septal thickening, distinguished vascular structures, halo, and inverted halo signs. In more severe conditions, crazy paving and fragmented consolidation may also occur [16]. Ground-glass appearance seen mainly on chest CT is estimated due to alveolar edema, exudation, and secondary bleeding resulting from inflammation [22]. The most common abnormalities on the CT-scan of 20 children with COVID-19 were subpleural lesions (100% patients), unilateral pulmonary lesions (30%) or bilateral (50%), GGO (60%), and halo sign (50%) [23].

A retrospective review of CT imaging and clinical symptoms from 30 children with COVID-19 confirmed through laboratory examinations in 6 centers in China from January to February 2020 indicates that CT findings are often negative (77%). GGOs with a peripheral lung distribution, crazy-paving, halo, and reverse halo signs were the CT findings observed in these pediatric patients. Eleven out of 30 patients had follow-up CT, demonstrating ten out of eleven patients had no changes, which leads to uncertainty in the benefit of CT for diagnosing and managing pediatric patients with COVID-19 [24].

Studies focusing on the relation of particular imaging features, clinical severity, and outcomes such as improvement, development, or mortality may improve the management of children with COVID-19. Moreover, due to the absence of long-term data, a future study investigating residual symptoms of the post-recovery disease, including changes in lung function and risk of developing permanent lung injuries such as pulmonary fibrosis, may be necessary.

4. Conclusion

Radiological features of COVID-19-induced pneumonia in children may differ from those in adults. In diagnosing COVID-19, we should prioritize the use of CXR. CT is necessary if there are pathological findings in radiography requiring further evaluation and clinically indicated. There are non-specific and superimposed findings with other types of viral pneumonia in thorax XR and CT of children with COVID-19. Additionally, they also have milder clinical symptoms, lesser observations in the CT, and minimum extensive involvement. The typical radiological findings of COVID-19 infection in children are patchy lesion, peribronchial distribution, and peribronchial cuffing.

Compliance with ethical standards

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Disclosure of conflict of interest

All author has no known conflict of interest.

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