Chest CT Features in Pediatric Patients with COVID-19 Infection: A Brief Review Article

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Abstract

Background

During the outbreak of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), fewer children were involved compared to adults, and fewer data about the chest computed tomography (CT) findings in children are available. The aim of this study was to review chest CT findings in children with COVID-19.

Materials and Methods: To perform this review study, the main databases of Medline (via PubMed), Scopus, EMBASE, and Google Scholar search engine were searched until May 2020 in English with keywords of "COVID-19, SARS CoV-2, Clinical Features, Children, Pediatrics, Chest CT, and Computed Tomography" were searched. The related studies were reviewed and selected by two reviewers. The kappa statistic between the two authors was 78% for selecting the articles.

Results: Based on the 17 evaluated studies, the most frequent abnormalities were respectively patchy shadowing, ground-glass opacities (GGOs), consolidations mostly surrounded with halo sign, and interlobular septal thickening. The lesions were commonly multiple, patchy, nodular, and bilateral; however, they could be single, local, unilateral, and dense in some cases; and most of the lesions have been detected in the right lower lobe.

Conclusion

Compared to adults infected with SARS CoV-2, the symptoms were milder and the lungs chest CT imaging indicated smaller lung involvement in pediatrics; however, the patterns of imaging changes were almost similar.

Key Words: Chest X-ray, Children, Computed Tomography, Coronavirus Diseases, COVID-19.

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1- INTRODUCTION

The outbreak of novel corona virus (SARS CoV-2) was declared as a pandemic by the world health organization (WHO) on March 11, 2020 (1). The virus was first discovered in Wuhan, Hubei Province, China on December 2019 (2). The disease caused by this virus officially named "coronavirus disease of 2019 (COVID-19)" by WHO on Feb 11, 2020. Currently, about 100,000 people have been infected in Iran and more that 3 million confirmed cases of COVID-19 have been reported all over the world. The infection is highly contagious with a human-to-human transmission by respiratory droplets and contact (2). In the early days of COVID-19 outbreak in China, it was thought that children cannot be infected by SARS CoV-19 or it would be rare. There is limited data about the involvement of children with the SARS CoV-2 infection. A review of 72,314 cases of COVID-19 in China on Feb 24, 2020 showed that less than 1% of the cases were children under 10 years old and about 1 % were between 10-18 years old (3).

Based on preliminary evidence, it is suggested that pediatrics can be infected but are less likely to be symptomatic and therefore, children can be potential careers. Children more often have gastrointestinal symptoms compared with adults (3). Even though the majority of patients were adults, the number of children who have been infected should not be underestimated. There are particular reasons that chest CT scans would be preferred to the reverse transcription polymerase chain reaction (RT-PCR) test. 1- The test can show false-negative results from pharyngeal swabs due to low viral load and it depends on the test takers' techniques. 2- It can show the presence of the virus not the progression of the disease. 3- it takes more time (1 or more days) compare with a chest CT scan and sometimes needs to be repeated 2 or 3 times to be positive. 4- It needs materials to be taken and the increasing number of patients would make it unable to take the test from all suspected patients in the near future. 5- It would not diagnose the patients in the early stages of the disease and they will miss the chance of early isolation and early treatment. 6- The quality of available SARS-CoV-2 nucleic acid detection kits differs greatly and it cannot be 100% reliable. In contrast, chest CT is simple to perform and readily available, can quickly detect lung lesions and make imaging diagnoses at the early stage. Therefore, it has great value in early screening, differential diagnosis, and the severity of COVID-19 (8).

Since most of the pediatric patients are mild cases, chest X-ray would fail to show the lesions or the detailed features, especially in the first stages (4). Therefore, early chest CT examination is very necessary. Previous studies also confirmed that the sensitivity of chest CT scan has been more than 90%, while the sensitivity of the test has been about 70 % for COVID-19 diagnosis (9). Consequently, the value of CT scans in the diagnosis and prognosis of COVID-19 is significant; while many studies have been conducted on COVID-19 in adults during the last two months, just few studies on COVID-19 in children are available. In this review study, the chest computed tomography changes in children with COVID-19 have been reviewed.

2- MATERIALS AND METHODS

To perform this brief review study, the main databases of Medline (via PubMed), Scopus, EMBASE, and Google Scholar search engine have been used. The keywords of "COVID-19, SARS CoV-2, clinical features, children, pediatrics, chest CT, and computed tomography" were searched. The articles selected in this brief review study included full articles, pre-proofs of the accepted article, pre-prints,

case reports, case series, and review studies published online up to 23 March, 2020, in English. Two reviewers screened a total of 62 studies which were related to clinical features of COVID-19 in pediatrics according to the titles and abstracts, then selected eligible studies for full revision based on the following inclusion criteria: 1- The subjects must have been under the age of eighteen. 2- The subjects must have been confirmed cases of COVID-19 by positive RT-PCR test. 3- At least one CT image with the exact report of findings must have been available for all the pediatric cases. The studies that reported other clinical manifestations, epidemiological factors, and laboratory data with no imaging report and chest CT scans were excluded. All disagreements were resolved through discussion with third party. The final list included 20 studies and their full texts were assessed and reviewed by the two reviewers. The kappa statistic between two authors was 78% for selecting the articles.

2-1. Ethical consideration

Ethical issues (including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been totally considered by all authors.

3- RESULTS

3-1. Chest CT findings in pediatrics

The totals of 17 publications were assessed and the results were analyzed. In a study on 20 children with COVID-19 pneumonia, CT images indicated bilateral and unilateral sub-pleural ground-glass opacities (GGOs) and consolidations with surrounding halo sign in the early stage. In the advanced stage, the scans showed expanded lesions with increased density and multiple lobes were involved; interlobular septal thickening, fibrosis lesions, and air bronchogram signs were also seen. In the critical stage, bilateral diffused consolidation lesions, air bronchogram sign, GGOs, and pleural thickening were detected. After treatment and in the recovery stage, 6 children were followed-up and the lesions had been absorbed in 2 cases, consolidations decreased and turned into GGOs in 3 cases, and residual fiber strip remained in 3 of them (4). Li et al. evaluated CT imaging findings in 5 children with positive COVID-19. 2 patients had no abnormalities in their chest CT scans, while 3 of them had involvements in the form of patchy GGOs in their first scans and the changes were disappeared after treatment (17). In a study on 6 known cases of COVID-19 from 1 to 7 years old, 2 cases had normal chest image. CT image finding revealed bilateral patchy shadows in 3 of them and bilateral patchy GGOs in the other one (18).

In a case series of 10 children infected by SARS CoV-19 with mild symptoms, chest X-ray (CXR) was performed for the patients. Unilateral patchy infiltration, opacities in the right lung, and retro cardiac opacities in the left lung were seen in four, three, and one of them respectively (19). In a study on 4 children with COVID-19, chest CT abnormalities were detected in 3 of them. The scans showed GGOs in a case and single consolidation in the right lower in another case. The third one had multiple consolidations plus pleural effusion which is usually not suggestive for COVID-19. In the follow-up CT scans, the images were still normal for the patient with a normal CT scan at the first. The other 3 patients with abnormalities in CT images showed improvement after 7 to 9 months. Additionally, peripheral patterns were not frequently seen in children, while most of them are in the peripheries in adults (13). Rahimzadeh et al., reported 9 Iranian children with COVID-19. Except for one

case, all of them had mild to moderate abnormal chest image findings. The findings were bilateral patchy consolidation with halo sign surrounded by GGOs. They also stated that diagnostic criteria and medical conditions of the patients were compatible with the abnormalities in CT scans (20). Ji et al. reported clinical features of 2 children with positive RT-PCR. The chest CT scans in both patients were normal and no abnormalities were detected (15). Tang et al., studied 26 children with novel coronavirus infection. While 8 patients had no changes in their chest CT images, 11 of them showed unilateral pneumonia with lateral pulmonary infiltration and 7 of them indicated bilateral pulmonary infiltration. All the patients were cured and none of them experienced severe respiratory complications (21).

In 2 studies on children with COVID-19, it was indicated that the symptoms and clinical manifestations of the infection in pediatrics are milder than adults and non-specific; and chest CT scans are useful to diagnose the infection at earlier stages. Their CT image findings showed bilateral multiple patchy shadowing, bilateral nodular GGOs, and speckled GGOs (22, 23). Chen et al., evaluated 31 confirmed cases of COVID-19 < 18 years old. GGOs were the most frequent abnormalities detected in their chest CT scans (24). Ma et al., evaluated 50 children with COVID-19. 43 patients had abnormalities in CT imaging. The most common findings were respectively GGOs, local patchy shadowing, and bilateral patchy shadows. Interstitial lesions were rare, pleural effusion was detected in one case, and no lymphadenopathy observed. The lesions were mostly located in the lower lobes, particularly in the posterior basal segment (25). In a study, the first newborn with COVID-19 from a confirmed infected mother in China was reported, and his RT_PCR test was positive 36 hours after birth. It has not been confirmed that if it was a vertical transmission. The CT findings showed high-density nodular shadow under the pleura of the posterior segment of the upper lobe in the right lung (26). A study on 13 infected children with SARS CoV-19 showed that the lung lesions were unilateral in 6 and bilateral in 10 of the patients (4). Zimmermann et al., performed a study on clinical features of infection with all coronaviruses (SARS-CoV, MERS-CoV, and SARS-CoV-2) in adults and children. They evaluated 3 case series of children with Covid-19 and stated that the most common findings of CT imaging were respectively bilateral multiple patchy nodular ground-glass opacities, speckled ground-glass opacities and/or infiltrating shadows. They concluded that the findings were mild and unspecific (27).

In a study on 1391 children, 171 of them had Covid-19 and the abnormalities in chest CT scans showed that 32.7% of the patients had GGOs in their scans. Local patchy shadowing (18.7%), bilateral patchy shadowing (12.3%), and interstitial abnormalities (1.2%) were the other patterns found in the scans (14). The chest CT of the first pediatric case of COVID-19, a 10-year-old girl, in Korea showed patchy nodular consolidations with peripheral GGOs (28). The chest CT images of a 55 day-old-girl with COVID-19 showed patchy shadows and GGOs which progressed within 2 days and absorbed after 5 days of hospitalization (29). In another study, among 8 infected children with SARS CoV-2 with severe symptoms, 6 of them had bilateral viral pneumonia and 2 had unilateral viral pneumonia. Multiple patchy shadows and GGOs were found in their CT images and one patients showed white-like-lung (30).

3-2. Summary of chest CT findings in adult patients

According to the revision of 10 studies recently performed on CT changes in adult

patients with COVID-19, the most frequent chest CT abnormalities were GGOs, consolidative opacities, and interlobular septal thickening respectively. The GGOs were mostly multiple, bilateral, and peripheral; however, they could be unifocal and unilateral in some cases. Consolidation opacities were seen in the peripheries in most of the cases. "Crazy-paving" pattern was also seen in most severe cases. Pleural effusions, lymphadenopathy, and cavities were not detected in any patient, which means these findings are not suggestive for covid19 pneumonia. The most common places where abnormalities have been detected were first the right lower lobe and then the left lower lobe (3, 8, 10-16).

4- DISCUSSION

The aim of this study is to review chest CT findings in children with COVID-19. Based on the results, the chest CT changes in most children were the milder forms of the changes in adult patients. To date in world the coronavirus COVID-19 is affecting 212 countries and territories around the world and 2 international conveyances. The number of 4,032,871 affected with this virus in world with 276,680 deaths. In Iran the number of 104,691 affected with this virus with 6,541 deaths. According to previous studies, gastrointestinal symptoms are more common in pediatrics (4), and the other clinical manifestations and chest CT findings were almost similar to adults; however, the symptoms were generally mild which would lead to missing the patients (5, 6). CT imaging is not sufficient to diagnose Covid-19, but it helps to manage and treat the patients in early stages as there have been children with low viral load in the Reverse transcription polymerase chain reaction test and early detection of lesions in CT imaging was helpful, particularly in case of co-infection with other micro-organisms (4). Moreover, the CT findings are not completely specific for COVID-10; for instance, consolidations are also common findings in Respiratory Syncytial Virus (RSV) infection (7). A total of 485 confirmed pediatric cases of COVID-19 have been evaluated in the 17 reviewed studies. Based on the results, their CT imaging findings showed that the most frequent abnormalities were respectively patchy shadowing, GGOs, consolidations mostly surrounded with halo sign, and interlobular septal thickening. The lesions were commonly multiple, patchy, nodular, and bilateral; however, they could be single, local, unilateral, and dense in some cases. Most of the lesions have been detected in the right lower lobe. What is significant is that the findings are not specific and can be found in pneumonia with other pathogens. Consequently, although chest CT scans are completely helpful for diagnosis, prognosis, and treatment particularly in early stages, epidemiological and etiological factors are needed to differentiate COVID-19 from other infections in pediatrics as children usually do not present severe symptoms of this viral infection.

4-1. Study Limitations

This review has particular limitations. Firstly, few numbers of studies on radiographic features of COVID-19 in pediatrics are available. Most of the studies have been conducted by Chinese researchers and data from other countries is limited. Ultimately, most studies just focused on the patterns of abnormalities, not on their distribution and involved segments.

5- CONCLUSION

Compared to adults infected with SARS CoV-2, the symptoms were milder and the lungs chest CT imaging indicated smaller lung involvement in pediatrics; however, the patterns of imaging changes were almost similar. Patchy shadowing, GGOs, consolidations mostly surrounded

with halo sign, and interlobular septal thickening were respectively most common chest CT findings in children with COVID-19.

6- AUTHOR CONTRIBUTIONS

SM, MS, MB and Y GH contributed to the conception of the work, MB, Y GH, and SM drafted the first draft of manuscript. Y GH and SM provided critical Comments for intellectual development of the paper. SM, MS, and MB edited the Whole article for scientific accuracy and is guarantor. All authors approved the final version of manuscript.

7- CONFLICT OF INTEREST: None.

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