RESEARCH ARTICLE

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Evaluation of Radiological Findings of Pediatric Cases Diagnosed with COVID 19 Infection: A Retrospective Study

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Objective: In this study, it was aimed to evaluate the effectiveness of chest radiography in the diagnosis of COVID-19 pneumonia in pediatric patients.

Materials and Methods: Between 2020 and 2021, radiological images of pediatric patients with diagnosed COVID-19 by polymerase chain reaction test were evaluated retrospectively. A total of 140 patients who underwent both lung X-ray and thorax computed tomography (CT) were included in the study. The effectiveness of chest radiography in the diagnosis of COVID-19 pneumonia was determined. Thoracic CT scans were compared in cases without pneumonia findings on chest X-rays.

Results: Covid-19 pneumonia was detected in 100 of 140 thorax CT. Increased opacity was observed in the chest X-ray of 48 of these 100 patients (48%). Radiographs of the other 52 patients were normal. The reasons for this were low-density opacities (n=26 patients, 50%), small-sized opacities (n=16 patients, 30.7%), opacities adjacent to the diaphragm and liver (n=10 patients, 19.2%). Consolidation was observed in 36 patients (36%) and a pure ground-glass appearance was observed in 64 patients (64%) on CT. An increased opacity was observed on chest radiographs in 26 (72.2%) of 36 patients with consolidation. In 22 (34.3%) of 64 patients with ground-glass appearance, increased opacity was observed on chest radiography. The consolidation detection rate of chest radiography was significantly higher than that of ground glass ($p < 0.01$).

Conclusion: Low-density opacities and small-sized opacities reduce the effectiveness of chest radiography. Although Chest X-ray imaging is useful in detecting consolidations in pediatric patients, it was not sufficient to detect ground-glass appearances.

Key Words: *COVID-19, pediatrics, radiological findings*

COVID 19 Enfeksiyonu Tanısı Alan Çocuk Olguların Radyolojik Bulgularının Değerlendirilmesi: Retrospektif Bir Çalışma

Amaç: Bu çalışmada, çocuk hastalarda COVID-19 pnömonisinin tanısında akciğer grafisinin etkinliğinin değerlendirilmesi amaçlandı.

Gereç ve Yöntem: 2020 ve 2021 tarihleri arasında, polimeraz zincir reaksiyonu testi ile COVID-19 tanısı alan çocuk hastaların radyolojik bulguları retrospektif olarak değerlendirildi. Hem akciğer grafisi hem toraks tomografisi çekilmiş 140 hasta çalışmaya dahil edildi. COVID-19 pnömonisinin tanısında akciğer grafisinin etkinliği belirlendi. Akciğer grafisinde pnömoni bulgusu saptanmayan olgularda toraks bilgisayarlı tomografileri karşılaştırıldı.

Bulgular: COVID-19 pnömonisi 140 toraks bilgisayarlı tomografinin 100'unde belirlendi. Bu 100 hastanın 48'inin akciğer grafisinde opasite artışı izlendi (%48). Diğer 52 hastanın radyografileri normaldi. Bunun sebepleri, düşük dansiteli opasiteler (n=26 hasta, %50), küçük boyutlu opasiteler (n=16 hasta, %30.7), diafragma ve karaciğere komşu opasitelerdi (n=10 hasta, %19.2). Bilgisayarlı tomografilerde, 36 hastada (%36) konsolidasyon, 64 hastada (%64) saf buzlu cam görünümleri izlendi. Konsolidasyonlu 36 hastanın 26'sının akciğer grafisinde (%72.2) opasite artışı izlendi. Buzlu cam görünümlü 64 hastanın 22'sinde (%34.3), akciğer grafisinde opasite artışı izlendi. Akciğer grafisinin konsolidasyon saptama oranı, buzlu cama göre anlamlı olarak yüksek bulundu ($p<0.01$).

Sonuç: Düşük dansiteli ve küçük boyutlu opasiteler akciğer grafisinin etkinliğini azaltmaktadır. Göğüs X-ray görüntüleme pediatrik hastalarda konsolidasyonları tespit etmede yararlı olmasına rağmen buzlu cam görünümleri tespit etmede yeterli olamamıştır.

***Anahtar Kelimeler*:** *COVID-19, pediatri, radyolojik bulgular*

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Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has caused a serious pandemic. Early diagnosis and timely isolation of infected people are very important to keep the pandemic under control. The Real-Time Polymerase Chain Reaction (RT-PCR) test obtained with respiratory secretion samples is the standard diagnostic method (1). However, low virus titers or technical problems in samples reduce the accuracy of RT-PCR outcomes and cause false-negative results (2). On the other hand, radiological imaging modalities; especially thorax CT has high sensitivity and can be evaluated rapidly (3).

COVID-19 pneumonia often causes important clinical symptoms. It is very common and contagious in the adult population. (4). The incidence is low in pediatric patients. It mostly manifests as asymptomatic or mild to moderate clinical symptoms. The incidence among children has been estimated to be between 1.7 and 2.4% (5, 6). In adults with COVID-19 pneumonia, a thorax CT scan is a useful diagnostic tool. However, if there are no significant symptoms, imaging is usually not necessary in pediatric patients to prevent radiation. When a child is clinically suspected of having COVID-19 pneumonia, lung radiography is the first imaging option. Thoracic CT should be performed in patients with moderate and severe symptoms and in suspicious chest radiography findings. Due to the good clinical course and low number patients, the number of reported literature on COVID-19 in children is limited compared to adults (7).

In the studies, it was found that the findings of adult thorax CT imaging were similar to those in children. However, studies on chest radiography findings are more limited and few in number. The aim of this study is to evaluate the efficacy of chest radiography in detecting COVID-19 pneumonia in pediatric patients and to determine the causes of false-negative lung radiography.

Materials and Methods

Research and Publication Ethics: The non-interventional research ethics committee has approved this study (Date: May 27, 2021; Number: 2021/07-42).

Between January 2020 and December 2021, radiological images of child patients diagnosed with COVID-19 by polymerase chain reaction (PCR) test were evaluated retrospectively. Chest radiographs with respiratory or motion artifacts were not included in the study. Thoracic CT had been performed in children with suspected Covid-19 symptoms such as fever and cough, dyspnea, myalgia, hypotension, diarrhea, loss of smell. The mean time between the appearance of the first symptoms and imaging was 3.5±3.3 (0-7) days. One hundred-forty patients who underwent both lung X-ray and thorax CT were included in the study. The median interval between chest X-ray and CT was 0 days (0-1 day). Radiological images were examined by the radiologist and pediatrician. COVID-19-related imaging abnormalities, such as ground-glass opacities, consolidations, and opacities distribution (unilateral or bilateral; central or peripheral), were assessed on all radiographs. By comparing the thorax CT findings to the chest X-ray findings, reasons for not detecting Covid-19 pneumonia on the chest X-ray were determined. The detection rate of ground glass and consolidation in chest X-ray were statistically compared.

Imaging Techniques: PA (posteroanterior) chest radiographs were performed on the digital X-ray devices with automatic exposure at the appropriate radiation dose for children. Single view PA chest X-ray examinations had been performed in an erect posture. According to the patient's age and weight, the exposure dose was varied between 70 kVp, 25 mAs and 100 kVp, 100 mAs. All thorax CT scans were performed without contrast on 128 multi-slice CT scan machines (Tube voltage depending on weight: 100–120 KV, slice thickness: 2.5 mm, pitch: 0.65, reconstruction interval: 5).

Statistical Analysis: IBM SPSS for Windows, version 25.0, was used to conduct statistical analyses (IBM statistics for Windows version 25). The chi-square test was used as a statistical analysis method. $p<0.05$ value was accepted statistically significant.

Results

One hundred-forty patients who underwent both lung X-ray and thorax CT were included in the study. Thoracic CT and chest radiography of 40 patients was normal. Covid-19 pneumonia was detected in 100 patients on thorax CT. The age of the patients was between 9 and 17. 80 patients were male, and 60 patients were female. There was no significant difference in age and gender between patients with pneumonia and the group without pneumonia (respectively $p=0.933$ and $p=0.418$).

Chest Radiography Evaluation: Increased opacity in the middle-lower zone was observed on 48 chest radiographs. Chest radiography was able to detect 48 (48%) of 100 patients with Covid-19 pneumonia. The opacities were unilateral in 36 patients (75%) and bilateral in 12 patients (25%). The most commonly affected areas were lower zones. Lower zones were affected in 30 patients (62.5%), middle zones were affected in 20 patients (41.6%). All opacities were located peripherally.

Thorax CT Evaluation: In 60 of the patients with Covid-19 pneumonia (60%), there was bilateral lung involvement and multiple lobe involvement. 40 patients (40%) had unilateral lung involvement. 45 patients (45%) had right lower lobe involvement and 35 patients (35%) had left lower lobe involvement. The right middle lobe (9%), left upper lobe (6%), and right upper lobe (5%) were other areas involved.

According to the characteristics of the lesions, 64 patients (64%) had a pure ground-glass appearance. Consolidation was observed in 36 patients (36%). Ground-glass appearance and consolidation were observed together in 30 patients (30%). Pure consolidation was detected in six cases (6%). The lesions were localized only peripherally in 60 cases (60%). Mixed (central and peripheral) localized lesions were observed in 40 cases (40%). Interlobular septal thickening was observed in 14 patients (14%) Crazy paving patterns, lymphadenopathy, and pleural effusion were not observed in any case.

Chest radiography of 52 patients with Covid-19 pneumonia was normal. Thoracic CT scans of these patients were analyzed. The reasons for this were low-density opacities (n=26 patients, 50%), small-sized opacities (n=16 patients, 30.7%), opacities adjacent to the diaphragm and liver (n=10 patients, 19.2%). On the

chest radiography of these 10 patients, the opacities were hidden by the right liver lobe and diaphragm.

Increased opacity was observed in the 26 chest radiograph of 36 patients with consolidation (72.2%). In only 22 of 64 patients with a ground-glass appearance on thorax CT, increased opacity was observed on chest radiography (34.3%). The consolidation detection rate of chest radiography was significantly higher than that of ground glass ($p<0.01$) (Table 1).

Figure 1. Unilateral increased opacity (green arrow) was observed on the chest radiography of a 13-year-old patient and consolidation was detected on the thorax CT

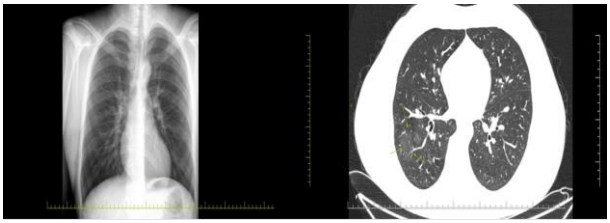

Figure 2. Chest radiography of the 14-year-old patient was normal. Ground-glass appearance (green arrows) was detected on thorax CT

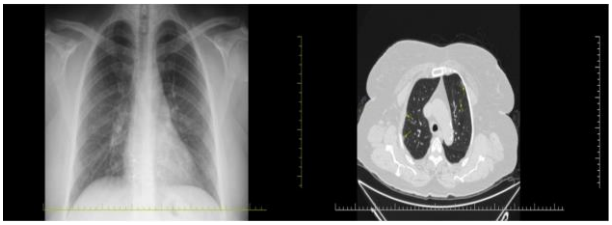

Figure 3. Chest radiography of the 16-year-old patient was normal. Small-sized opacities (green arrows) were detected on thorax CT

Table1. Efficiency of chest X-ray in detecting ground glass and consolidation

	Thorax CT	Chest X-ray	P
Consolidation	36	26	p<0.01
Pure ground-glass appearance	64	22	

Discussion

Typical COVID-19 pneumonia findings on thorax CT have been described for adults. The most common finding is peripherally located, multifocal ground-glass opacities that begin in the lower lobes (8). The prominence of vascular structures, interlobular septal thickening, halo, and reverse halo appearance are other radiologic findings. Crazy paving patterns and prominent consolidations are seen in advanced cases. The ground-glass appearance is thought to be caused by exudation, alveolar edema, and secondary bleeding (9).

If there is no clinical symptom, imaging is not generally necessary in pediatric patients in order to avoid radiation. Chest radiography is initially preferred as a radiologic modality in pediatric cases who are clinically suspected of having COVID-19 pneumonia. Studies on chest radiography in the pediatric group are limited in the literature. In our cases with COVID-19 pneumonia, the most common radiological finding on lung radiographs was unilaterally increased opacity, especially in the lower zones. Opacities were mostly bilateral on CT. Thorax CT is superior to chest radiography in showing the extent of the disease.

Li et al. (10) reported that multifocal and bilateral involvement was common on thorax CT of pediatric cases with COVID-19 pneumonia. They also reported that the combination of consolidation and ground-glass was seen more often than in adults, but less interlobular septal thickening and crazy paving pattern. In our cases, interlobular septal thickening was observed in only 14 patients. Atypical findings such as crazy-paving pattern, lymphadenopathy, and pleural effusion were not observed in any case. It should be known that pleural effusion may accompany in severe patients (6).

Pediatric patients should be protected from unnecessary radiation. In case of suspicious findings on chest radiography and clinical necessity, thorax CT examination will be appropriate. In patients with a negative PCR test whose chest radiograph is normal or indeterminate, thoracic CT should be performed if moderate-to-severe symptoms are present. In addition, thoracic CT should be performed if oxygen saturation is below 93 percent despite mild symptoms and normal/indeterminate chest radiography (11).

According to our findings, chest radiographs in pediatric patients detect COVID-19 pneumonia mostly at the stage of consolidation. It can be difficult to detect ground-glass opacities on chest radiographs without consolidation. Low-density opacities and small-sized opacities of detection are difficult on chest radiography. However, we consider that the few ground-glass opacities that may be overlooked have no clinical significance if the patient has mild symptoms.

Duan et al. reported that as the clinical course of the disease worsened, the ground-glass appearance expanded, its density increased and transformed into multiple consolidations (12). Chest X-ray detects Covid-19 pneumonia more easily as the clinic worsens. Therefore, chest radiography is used in the radiological and clinical follow-up of patients.

In the early stage (0–4 days following the onset of the first symptom), ground-glass appearance are the main radiological findings. In the progressive stage (5–8 days), infection is extended to a multi-lobar distribution with ground-glass opacities and consolidation. In the peak stage (9–13 days), dense consolidation becomes the dominant finding (13).

Consolidation is observed in progressive and peak stages. Therefore, chest radiography is more useful at these stages (5-13 days). According to us, chest radiography is unnecessary in the early stage (0–4 days), especially in patients with mild symptoms.

The limitations of the study are its retrospective nature, low number of patients, and single-center design.

As a result, the COVID-19 clinic has a milder course in the childhood age group. Radiological imaging should be performed according to the clinical situation in order to protect children from unnecessary radiation. Especially ground glass appearance and consolidation are seen in child patients with COVID-19 pneumonia. Generally, chest radiography is preferred firstly. But chest radiography has some limitations in detecting Covid-19 pneumonia. It is not successful in detecting ground-glass appearances. Chest radiography is more useful in the consolidation stage. Low-density opacities and small-sized opacities reduce the effectiveness of chest radiography.

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