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WORD COUNT	2205	TIME SUBMITTED	25-JUL-2022 01:55PM
		PAPER ID	88774690

Name of Journal: *World Journal of Virology*

Manuscript NO: 77316

Manuscript Type: ORIGINAL ARTICLE

Retrospective Study

Effect of age on CT findings: specificity and sensitivity in COVID-19 infection

Running title: Effect of age on CT findings in COVID-19 infection

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Abstract

BACKGROUND

COVID-19 is a pandemic caused by the severe acute respiratory syndrome coronavirus (SARS-CoV-2) in 2019. Although the real-time reverse transcription polymerase chain reaction (RT-PCR) test for viral nucleic acids is the gold standard for COVID-19 diagnosis, computerized tomography (CT) has grown in importance.

AIM

To evaluate the sensitivity and specificity of thoracic computed tomography (CT) findings of 2019 novel coronavirus disease (COVID-19) pneumonia according to age groups.

METHODS

411 patients with PCR and CT results were reviewed. The diagnosis of COVID-19 pneumonia was made by three radiologists. Lymphadenopathy, pericardial effusion, pleurisy, pleural thickening, pleural effusion, location features of the lesions, ground glass, consolidation, air bronchogram, vascular enlargement, bronchial dilatation, halo finding, inverted halo sign, nodularity, air bubble, subpleural band (curvilinear density), reticular density, crazy paving pattern, and fibrosis findings were recorded. The patients were divided into 9 groups in decades while calculating the sensitivity, specificity and diagnostic efficacy for CT positivity.

RESULTS

The mean age of the cases was 48.1±22.7. The CT finding with the highest diagnostic power was ground glass. Vascular enlargement and bronchial dilatation follow ground glass. Pericardial effusion is the finding with the lowest diagnostic accuracy. The incidence of lymphadenopathy, pleurisy, pleural thickening, peripheral localization, bilateral, ground glass, vascular enlargement, bronchial dilatation, subpleural band, reticular density, crazy paving appearance and fibrosis all increase with age findings

increase significantly with age in patients with positive Real-time reverse transcription polymerase chain reaction (RT-PCR) test.

CONCLUSION

There are few publications comparing sensitivity and specificity of thorax CT findings according to age. In cases of COVID-19 pneumonia, there is an increase in the variety and frequency of CT findings with age and parallel to this, the sensitivity and specificity of the findings increase. COVID-19 cases in the pediatric age group have fewer lung findings than adults, and this situation decreases the diagnostic value of CT in pediatric patients.

Key Words: Thoracic CT; COVID-19; Pediatric age.

Karavas E, Unver E, Aydın S, Yalcin GS, Fatihoglu E, Kuyrukluyildiz U, Arslan YK, Yazici M. Effect of age on CT findings: specificity and sensitivity in COVID-19 infection. *World J Virol* 2022; In press

Core Tip: Despite its high sensitivity for identifying COVID-19 pneumonia, the diagnostic potential of CT findings has not been thoroughly investigated, particularly in relation to age subgroups. It's worth noting that the prevalence of COVID-19 pneumonia can vary by age. Even common results, such as ground glass opacities, can be reduced in younger individuals, particularly in the pediatric population. Additionally, the findings of this study may raise awareness about the proper use of CT scans in children and contribute to radiation protection by limiting CT scans in age groups with low sensitivity.

INTRODUCTION

The World Health Organization has declared 2019 novel coronavirus disease (COVID-19) a pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-

2) [1,2]. Although fever and cough are the most common clinical symptoms, other symptoms such as fatigue, shortness of breath, and headache may also be present (3). However, because all of these symptoms are not unique to the disease and because the disease can progress quickly to severe pneumonia, diagnostic tests are required. Although the real-time reverse transcription polymerase chain reaction (RT-PCR) test for viral nucleic acids is the gold standard in the diagnosis of COVID-19, computerized tomography (CT) has become increasingly important in the diagnosis due to false negative results and the inability to obtain results quickly(4). Because CT has a sensitivity of 97 percent, it is frequently used, and algorithms are developed accordingly (5). Even if the RT-PCR is negative treatment and filiation are initiated in close contacts (6). However, because CT contains ionizing radiation, there is a risk of unintentional use. The expected harms of ionizing radiation are greater in children than in adults. Seeing that, we aim to define the change of the CT findings, as well as the sensitivity and the specificity of these findings according to age

MATERIALS AND METHODS

Study design

The local (33216249-50.01.02-E.25467) medical ethics committee approved this study. The ethics committee waived informed consent as a result of the retrospective nature.

The study included 411 patients with suspected COVID-19 who applied to a tertiary health care center. The registration period began on March 15, 2020, and ended on May 15, 2020. All patients had laboratory RT-PCR testing of respiratory secretions obtained *via* nasopharyngeal or oropharyngeal swab. Clinical data from electronic medical records were reviewed.

All patients had a CT scan without intravenous contrast material on the day they were admitted to the hospital(Siemens SOMATOM Sensation 16, Forchheim, Germany). All patients were scanned in the supine position using an adult CT protocol; reconstruction images of the 1.5 mm lung window were obtained using tube voltage=130kV, effective mAs=70, slice thickness=5 mm, collimation=16x1.2, pitch=0.8. In children,

reconstruction images of the lung window of 1.5 mm were obtained with protocol tube voltage=110kV, effective mAs=60, slice thickness=8 mm, collimation=16x1.2, pitch=0.8 (14 years and younger).

All CT images were reviewed by three thorax imaging experts who were not aware of the RT-PCR test results, and the final decision was reached by consensus. The North American Society of Radiology Expert Consensus Statement on Reporting of Lung CT Findings Related to COVID-19 (7) (Radiological Society of North America Expert Consensus Statement on Reporting Chest CT Findings Related to COVID-19) was followed in the evaluation for pneumonia caused by COVID 19. Atypical appearance and negative for pneumonia were considered positive for COVID 19 infection, whereas atypical appearance and negative for pneumonia were considered negative for infection. Lymphadenopathy, pericardial effusion, pleurisy, pleural thickening, pleural effusion, lesion location features (peripheral-central-diffuse, posterior, bilateral-unilateral, *etc.*), ground glass, consolidation, air bronchogram, vascular enlargement, bronchial dilatation, halo sign, reverse halo sign, nodularity, air bubble, subpleural band (curvilinear density), reticular density, crazy paving pattern, and fibrosis findings were recorded.

The patients were divided into 9 groups in decades when calculating the sensitivity, specificity, and significance for CT positivity. 9^{th} the group was defined as people aged 80 and up. To avoid decreasing statistical power, the sensitivity, specificity, and significance of the CT findings were divided into three groups determined by the World Health Organization (Age group 1: 0-18, Age group 2: 18-60, Age group 3: 60 and above).

Statistical analysis

IBM SPSS 22 was used for statistical analyses (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.). The Kolmogorov-Smirnov test was used to determine whether the data conformed to a normal distribution. Numerical variables with a normal distribution were represented as mean

standard deviation (SD) values, variables without a normal distribution as median (minimum-maximum) values, and categorical variables as number (n) and percentage values (percent)When calculating CT diagnostic accuracy measures, RT-PCR was used as the gold standard. CT sensitivity and specificity were reported along with their 95% confidence intervals (CI). Exact Clopper-Pearson confidence intervals (CIs) for sensitivity and specificity were calculated. A P value of less than 0.05 considered as statistically significant.

RESULTS

The average age of the 411 cases was 48.1±22.7 (median: 49, range: 0-99), with 241 (58.8%) males and 170 (41.4%) females. Figure 1 depicts the distribution of the number of patients by decade, while Figure 2 depicts the distribution by group. There were 181 positive RT-PCR results and 230 negative RT-PCR results out of 411 patients, for a positive rate of 41% (181/411). There was no statistically significant difference in age or gender between patients with positive and negative RT-PCR results (*P*>0.05). There were 141 positive and 40 negative CT findings in 181 cases, for a positive rate of 77.9 %(141/181?). The overall and age-segregated sensitivity and specificity of CT were calculated and reported based on RT-PCR results. CT sensitivity was found to be 77.9 % (95%CI: 71.15 to 83.72) for all patients. However, when the sensitivity value was stratified based on age, it was discovered that it had changed. The findings revealed that the sensitivity of CT increased with age (Table 1, Figure 3, 4).

Table 2 showed the diagnostic accuracy of the findings recorded in RT-PCR test negative and positive cases across the entire population. According to these findings, ground glass opacity the highest diagnostic accuracy of 62.5 percent (sensitivity 84.4%, specificity 33.7%), followed by vascular enlargement at 58.5% and bronchial dilatation at 58.3% (Figure 5). With a diagnostic accuracy of 40%, pericardial effusion is the finding with the lowest diagnostic accuracy.

Table 3 showed the frequency of findings in cases with positive RT-PCR tests based on age groups. Lymphadenopathy, pleurisy, pleural thickening, peripheral localization, bilateral, ground glass, vascular enlargement, bronchial dilatation, subpleural band, reticular density, crazy paving appearance and fibrosis all increase with age (P <0.05) (Figure 6). Although there was a significant difference in consolidation, air bronchogram, and air bubble findings between age groups, it was not related to patient age (Figure7). There was no significant difference in the rates of bilateral involvement, posterior location, pericardial effusion, halo, reverse halo, and nodularity between the three groups (P >0.05) (Figure 8).

DISCUSSION

March 11, 2020, the World Health Organization declared COVID-19 a global epidemic. The disease's high contagiousness necessitates the development of a rapid and highly sensitive test. In addition to the low sensitivity of the gold standard RT-PCR test, test results could be provided within days or weeks due to a lack of testing centers, particularly in the first months of the pandemic. This circumstance has resulted in a more rapid and accessible test requirement. The impact of COVID 19 infection on the lower respiratory tract has brought thorax CT examination to the forefront. Thoracic CT is useful for detecting viral lung infection, determining the nature and extent of pulmonary lesions, and monitoring disease activity(8–11). In addition, latest studies also revealed that CT perfusion examinations can reveal perfusion deficits in COVID-19 pneumonia (12). In these circumstances, In addition to the potential for rapid diagnosis of COVID-19 by thorax CT, identification of pulmonary changes and base images of the cases to be followed may be an added benefit.

Multiple, peripheral, bilateral, irregular, subsegmental or segmental ground glass opacities, mostly bronchovascular bundles, and areas of consolidation scattered throughout the subpleural space are typical COVID-19 chest CT imaging features. The presence of associated intralobular septal thickening in areas of ground glass opacity, crazy paving appearance, consolidation, and air bronchograms with areas of bronchial

wall thickening, and, less frequently, thickening of the adjacent or interlobar pleura, as well as a small amount of pleural effusion (7,13,14). When all cases were considered in our study, the findings of ground glass density, vascular enlargement, bronchial dilatation, consolidation, and bilaterality stood out as diagnostic accuracy.

In limited studies, pediatric patients with COVID-19 have relatively mild clinical symptoms, a higher prevalence of negative CTs, and atypical, peribronchial distribution of lung opacities and bronchial wall thickening are more common(15,16). The incidence of any finding other than an air bronchogram and nodular appearance is not higher in this age group than in other age groups. Posterior location, bilaterality, and ground glass density are the most common findings. Among these findings is that the prevalence of ground glass density is significantly lower in this age group than in other age groups. The sensitivity of CT diagnosis in the 0-9 age group was found to be quite low in our study.

For the diagnosis of COVID-19, various algorithms have been developed. Due to the large number of cases, doctors from fields other than chest diseases or infectious diseases had to play an active role in disease diagnosis in many hospitals. Due to a lack of experience in physical examination, doctors from various fields frequently rely on Thorax CT examination, with the tendency to deviate from algorithms and make an easy and quick diagnosis. RT-PCR may be negative in the early stages of the disease and due to other variants, as well as the RT-PCR tests inadequacy contributes to the overuse of Thorax CT (17,18).. It does not recommend routine thoracic CT screening for COVID-19, and confirmatory diagnosis is based on RT-PCR. When a low-dose CT scan is required, it is preferable for the pediatric population. Follow-up imaging is only necessary in cases of clinical deterioration and should be kept to a minimum.

The study's most significant limitation is the small number of cases in the 0-18 age range. The main reason for this is that clinical symptoms in this age group are unclear, and pediatricians in our hospital are actively treating patients with suspected COVID-19.

CONCLUSION

To summarize, despite its high sensitivity for identifying COVID-19 pneumonia, the diagnostic potential of CT findings has not been thoroughly investigated, particularly in relation to age subgroups. It's worth noting that the prevalence of COVID-19 pneumonia can vary by age. Even common results, such as ground glass opacities, can be reduced in younger individuals, particularly in the pediatric population. Additionally, the findings of this study may raise awareness about the proper use of CT scans in children and contribute to radiation protection by limiting CT scans in age groups with low sensitivity.

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