RESEARCH LETTER

Usefulness of a portable chest radiograph in the initial diagnosis of coronavirus disease 2019

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Introduction A large number of patients with a suspicion of coronavirus disease 2019 (COVID-19) arrive at hospitals, in which limited isolation options are available, and often wait a long time to have a reverse transcription–polymerase chain reaction (RT-PCR) test performed. This calls for the implementation of efficient triage measures. A patient is admitted or not based on their medical history, a simple physical examination, blood test results, and imaging findings. Numerous reports have shown that chest computed tomography (CT) has a high sensitivity in the screening and diagnosis of COVID-19 pneumonia.[1] However, CT might be oversensitive, as it does not detect features unique to the disease, especially during its initial stage.[2] The routine order of CT scans also results in the additional use of personal protective equipment by the radiology department staff and the risk of transmitting the virus by clustering infected and noninfected patients. Currently, the use of CT is not recommended as a first-line test for the screening and diagnosis of COVID-19 pneumonia.[3] Owing to epidemiological conditions, portable chest radiograph use is a preferred approach.[4] The American College of Radiology suggests that this modality may be considered to minimize the risk of cross-infection and CT should be used sparingly in hospitalized patients, based on specific clinical indications.[3] The British Society of Thoracic Imaging has also admitted that a combination of clinical, laboratory, and portable chest X-ray (CXR) findings could be used to triage patients with a suspicion of COVID-19 in line with hospital admission recommendations, and CT should be reserved for more challenging scenarios.[5]

Methods Our retrospective analysis included the medical records of 152 consecutive symptomatic patients infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) who presented to the Gromkowski Regional Specialist Hospital in Wrocław (Poland) between March 6, 2020 and April 16, 2020 and had CXR performed on the day of admission. All cases of infection were confirmed with a RT-PCR test performed on the same day.

The CXR results were analyzed by a radiologist and evaluated according to the chest radiograph scoring system proposed by Taylor et al.[5] Portable chest X-ray findings were categorized as: 1—normal; 2—patchy atelectasis and/or hyperinflation and/or bronchial wall thickening; 3—focal consolidation in a single lobe; 4—multifocal and bilateral consolidations; and 5—diffuse alveolar lesions.[5]

The examination report, in addition to the CXR result, comprised the patient's medical history, symptoms and their duration, oxygen saturation, laboratory test results: complete blood count, capillary blood gas, and the levels of C-reactive protein (CRP), lactate dehydrogenase (LDH), alanine aminotransferase, D-dimer, and ferritin. Disease severity was evaluated according to the World Health Organization definition (mild, moderate, or severe, including critical disease).[6]

Neither ethics committee approval nor written patient consent were required, as it was a retrospective study based on medical records.

Statistical analysis Nonparametric statistics was used to compare categorical variables between the study groups. To compare scores between 2 groups, we used the Mann–Whitney test, and to compare more than 2 groups, we used the Kruskal–Wallis test with the Games–Howell post hoc test. The correlation between scores and quantitative variables was assessed using the Spearman rank correlation

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TABLE 1 Baseline characteristics, symptoms, and laboratory test results of the study patients

Variable		Value	*P* value for the correlation between the variable and the number of points in the CXR score
Demographics			
Age, y, mean (SD); range		56.6 (16.8); 19–96	<0.001
Sex, n		73 M, 79 F	0.14
Concomitant diseases			
Any		83 (54.6)	–
Cardiovascular diseases (including hypertension)		66 (43.4)	0.04
Pulmonary diseases		14 (9.2)	0.13
Malignancy		19 (12.5)	0.32
Obesity		22/83 (26.5)	<0.001
Diabetes		19 (12.5)	0.06
Disease severity			
Mild (1)		90 (59.2)	<0.001 between groups 1–2 and 1–3; 0.7 between groups 2–3
Moderate (2)		42 (27.6)	
Severe (3)		20 (13.2)	
Clinical symptoms			
Fever		125/150 (83.3)	0.49
Cough		114/150 (76)	0.57
Dyspnea		79/151 (52.3)	0.001
Oxygen saturation <94%		47/152 (30.9)	<0.001
Laboratory data			
CRP	>6 mg/l	111/143 (77.6)	0.02
	>100 mg/l	34/143 (23.8)	<0.001
Ferritin >291 ng/ml		20/28 (71.4)	0.007
D-dimer >500 ng/ml		50/69 (72.5)	<0.001
Lymphopenia $<1 \times 10^3/\mu l$		49/135 (36.3)	0.33
LDH >246 U/l		40/54 (44.6)	<0.001
ALT >48 IU/l		58/130 (44.6)	0.002
Outcomes			
Hospitalization time, d, mean (SD); range		14.2 (9); 1–69	0.001
Death, n		16	<0.001

Data are presented as number (percentage) of patients unless otherwise indicated. Data are reported for a total of 152 study patients unless otherwise shown (values after the forward slash represent the number of patients in whom data were available).

Abbreviations: ALT, alanine transaminase; CRP, C-reactive protein; CXR, chest X-ray; F, female; LDH, lactate dehydrogenase; M, male

coefficient. A *P* value less than 0.05 was considered significant. Calculations were performed using the R software for Windows, version 4.0 (GNU General Public License, Boston, Massachusetts, United States).

Results A total of 77/152 of patients (50.7%) who presented to the hospital had radiologically confirmed pneumonia: CXR score, 2–5 points (2 points—11 patients [7.2%]; 3 points—21 [13.8%]; 4 points—38 [25%]; and 5 points—7 [4.6%]). The time between the onset of symptoms and subsequent CXR ranged from 1 to 23 days (mean [SD], 6.5 [4.5]days). The mean duration of symptoms was 7.4 days in patients with inflammatory lesions and 5.8 days in those without pneumonia ($P < 0.01$). Pneumonia was more common in obese patients and those with cardiovascular diseases. No correlation was found for pulmonary diseases, diabetes, and malignancy. A positive correlation was found between age and pneumonia, with morbidity increasing with age ($P < 0.001$). There was no relationship between sex and pneumonia. A significant difference was found between disease severity and the presence of pneumonia, duration of hospitalization, and mortality risk. Another positive correlation was found between dyspnea and pneumonia on CXR. No significant differences were seen for age and fever as well as age and dyspnea ($P = 0.42$). Cough was the most common symptom observed in younger study patients below 60 years of age ($P = 0.01$) (TABLE 1).

A decreased blood saturation was observed in 47/152 patients (30.9%); all abnormal results were confirmed using a capillary blood gas test. A total of 8/47 individuals (17%) had radiologically confirmed pneumonia. A strong correlation was present among decreased saturation, pneumonia, and advanced age. Notable, diffuse inflammatory lesions (grade 4 and 5) were found in 21/34 patients (61.8%) with CRP ≥100 mg/l. The analysis confirmed a strong correlation between the CRP level and the presence and increased severity of inflammation in the lungs. A similar correlation was noted with respect to LDH, alanine aminotransferase, D-dimer, and ferritin levels. No correlation regarding the presence or lack of lymphopenia was found (TABLE 1).

Discussion Here, we evaluated the correlation between CXR findings and the patient's clinical status, including laboratory test results. It was the first study to prove the diagnostic usefulness of CXR-based triage at the initial presentation of patients with a suspicion of COVID-19. Our findings indicated that the initial use of a portable radiograph is a valuable supplementary test in diagnosing patients with COVID-19. The 5-point scale for evaluating chest imaging provides reliable information on inflammation severity.

The analysis showed a correlation between the severity of COVID-19-related pulmonary disease and age. Due to the relatively small number of study patients in particular age groups, we could not determine the critical age at which the risk of severe pulmonary disease increases considerably. Such an analysis of 783 hospitalized patients was conducted by the Italian authors.[7] They concluded that men aged ≥50 years and women aged ≥80 years are at the highest risk of developing severe pulmonary disease.[7]

We also assessed the correlation between the presence of pneumonia and selected components of the clinical status and blood test results. Such correlation was found between laboratory inflammatory markers and CT findings. In a group of 42 patients, Xiong et al[8] proved that clinical findings and white blood cell count did not correlate well with initial CT findings; CRP and LDH levels as well as the erythrocyte sedimentation rate were positively correlated with the extent and severity of pneumonia assessed on initial CT.

So far, no reliable study results referring to the presence and severity of inflammatory pulmonary lesions on CXR with respect to disease duration have been published. It is known that initial CXR and CT may be normal in COVID-19. The rates of unremarkable baseline imaging depend on disease severity and the timing of imaging performance.[9,10] Lung opacities may rapidly, within 1 to 3 weeks after disease onset, evolve into a diffuse coalescent or consolidative pattern. Bernheim et al[10] assessed the CT scans of 121 symptomatic patients and noted no lesions in 56% of the patients presenting with early symptoms (0–2 days between symptom onset and initial CT), and the likelihood to report abnormal CT findings increased with the time that elapsed from symptom onset.[10] In our study, longer duration of symptoms was correlated with a higher CXR score. Due to group heterogeneity, we could not indicate on which day after symptom onset pulmonary lesions might be expected.

The analysis of 152 CXR images proved its usefulness in diagnosing pneumonia. A wide variety of images showing overlapping chronic pulmonary lesions or lack of features specific to SARS-CoV-2 infection means that diagnosing COVID-19-related pulmonary disease relying solely on CXR poses a high risk of making an error, especially in the very early and very late stages of the disease. There is no doubt that CXR is a less sensitive modality for chest imaging than CT, particularly in patients with a mild disease course. According to the literature, chest X-rays in COVID-19 pneumonia usually demonstrate bilateral air-space opacification, which was confirmed in our analysis. In turn, the most common features seen on CT, namely, ground glass opacities, are more difficult to detect by CXR, especially at the early stage of the disease.[9-10] For example, in a study by Guan et al[9] including 274 patients, lesions were notable in 59.1% of patients (nonsevere, 54.2%; severe, 76.7%) on CXR, and in 86.2% (nonsevere, 84.4%; severe, 94.6%) on CT. In turn, an Italian study showed an 89% sensitivity and a 60.6% specificity of CXR.[11] The authors concluded that using CXR alongside RT-PCR testing to triage patients with a suspicion of SARS-CoV-2 infection is a chance to avoid potential false negative RT-PCR test results.[11]

The British Society of Thoracic Imaging has published a radiology decision-making tool for suspected COVID-19, which initially recommended physicians to perform CXR not only in seriously ill patients but also in stable individuals if imaging is clinically required. Computed tomography is recommended in seriously ill patients whose CXR is unclear or normal. It is also useful in diagnosing patients with pre-existing pulmonary diseases and complications as well as in investigating a discordant clinical presentation.[1] A similar approach can be found in the Polish diagnostic, therapeutic, and organizational recommendations.[12]

Conclusions In conclusion, the presence and severity of inflammatory lesions evaluated by a simple 5-point CXR scale was significantly correlated with patients' age, clinical status, and blood test results. A portable chest radiograph can be used to evaluate the severity of the disease course and prognosis. It should be regarded as an initial imaging modality in the treatment protocol for patients with a suspicion of COVID-19.

ARTICLE INFORMATION

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CONTRIBUTION STATEMENT MR conceived the concept of the study. MR and KS contributed to the study design. MR, AZ, and WS were involved

in data collection. MR and MG analyzed portable chest X-ray results. MR, MG, and KS analyzed the data. MR coordinated funding for the project. All authors edited and approved the final version of the manuscript.

CONFLICT OF INTEREST None declared.

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REFERENCES

1 Nair A, Rodrigues JCL, Hare S, et al. A British Society of Thoracic Imaging statement: considerations in designing local imaging diagnostic algorithms for the COVID-19 pandemic. Clin Radiol. 2020; 75: 329-334.

2 Raptis CA, Hammer MM, Short RG, et al. Chest CT and coronavirus disease (COVID-19): a critical review of the literature to date. AJR Am J Roentgenol. 2020; 215: 839-842.

3 The American College of Radiology Recommendations for the use of chest radiography and computed tomography (CT) for suspected COVID-19 infection. March 22, 2020. https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Recommendations-for-Chest-Radiography-and-CT-for-Suspected-COVID19-Infection. Accessed June 7, 2020.

4 Rubin GD, Ryerson CJ, Haramati LB, et al. The role of chest imaging in patient management during the COVID-19 pandemic: a multinational consensus statement from the Fleischner Society. Chest. 2020; 158: 106-116.

5 Taylor E, Haven K, Reed P, et al. A chest radiograph scoring system in patients with severe acute respiratory infection: a validation study. BMC Med Imaging. 2015; 15: 61.

6 World Health Organization. Clinical management of COVID-19. May 27, 2020. https://www.who.int/publications/i/item/clinical-management-of-covid-19. Accessed July 6, 2020.

7 Borghesi A, Zigliani A, Masciullo R, et al. Radiographic severity index in COVID-19 pneumonia: relationship to age and sex in 783 Italian patients. Radiol Med. 2020; 125: 461-464.

8 Xiong Y, Sun D, Liu Y, et al. Clinical and high-resolution CT features of the COVID-19 infection: comparison of the initial and follow-up changes. Invest Radiol. 2020; 55: 332-339.

9 Guan WJ, Ni ZY, Hu Y, et al. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med. 2020; 382: 1708-1720.

10 Bernheim A, Mei X, Huang M, et al. Chest CT findings in coronavirus disease-19 (COVID-19): relationship to duration of infection. Radiology. 2020; 295: 200463.

11 Schiaffino S, Tritella S, Cozzi A, et al. Diagnostic performance of chest X-ray for COVID-19 pneumonia during the SARS-CoV-2 pandemic in Lombardy, Italy. J Thorac Imaging. 2020; 35: W105-W106.

12 Agency for Health Technology Assessment and Tariff System. Recommendations in COVID-19. Polish diagnostic therapeutic and organizational recommendations for care of the infected or the exposed to infection with SARS-CoV-2. Version 1.0. April 24, 2020 https://www.aotm.gov.pl/www/zalecenia-covid-19-2/. Accessed June 7, 2020.