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Role of Chest X-ray abnormalities in predicting outcome of COVID-19 in Young Adult Patient

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Article Info

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Abstract

COVID-19 is a highly infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-COV-2). Recently COVID -19 radiological literature focuses primarily on CT scan findings which are more sensitive (about 97%) and specific than chest x-ray. But it has to be remembered that performing CT scan is not easy during this pandemic situation. So, the aim of the study was to analyze the chest x-ray severity scoring system and its association with outcome in a young adult patient with COVID-19. This cross-sectional study was carried out from September 15 to December 31 2020 in the COVID unit of BSMMU and it included 100 RT-PCR positive COVID-19 patients according to selection criteria. Chest x-ray postero-anterior view was done in the radiology department of BSMMU. Each patient's chest x-ray was examined by a radiologist and a pulmonologist with experience of 10 years. Radiological scoring was done by using a scoring system. All patients were followed after 20 days from the first presentation to see the outcome. Out of 100 patients, 73 patients (73%) needed hospital admission, 33(33%) patients were hospitalized but did not developed sepsis, 29 (29%) patient developed sepsis, 10(10%) patient needed ICU support among them 2 patients got intubation. 1(1%) patient was dead. Radiological score ≥ 4 was associated with increased risk of hospitalization. (Area under curve = 0.956). Score ≥ 5 was associated with increased risk of sepsis; score ≥7 was associated with increased risk of ICU admission. (p-value<0.001).

Introduction

Corona virus disease 19 (COVID-19) disease has emerged as unprecedented health care as well as an economic crisis.[1] It is a highly infectious disease caused by severe acute respiratory syndrome coronavirus (SARS-COV-2). It was declared as a pandemic condition by the World health organization on 11th March 2020.[2] 1st case of COVID-19 was recognized in Wuhan china in late 2019. Within a short period of time the disease has been spread worldwide and affected about 223 countries. Almost 120 million people are affected and 2.6 million people are dead. In Bangladesh 1st case was detected on 8th March 2020. Since then the numbers of cases are increasing day by day and more than 5lac people are affected and eight thousand people are dead while writing.[3]

Droplet transmissions followed by contaminated surfaces are believed to be the main modes of spread for SARS-COV-2.[1] The average incubation period is 14 days.[4] Symptoms of the infection are variable and nonspecific.50% of patients have no obvious symptoms. Commonly patients present with fever, dry cough, fatigue, loss of smell, loss of taste. Besides respiratory symptoms patients are presented with gastrointestinal symptoms like loss of appetite, nausea, vomiting and diarrhea.[5] Older male patients with co-morbidities are more prone to be infected with unfavorable outcome like severe pneumonia, acute respiratory distress, multiple organ failure, and death.[6]

Respiratory system involvement is common in COVID 19 diseases, that's why chest imaging plays a vital role in diagnosis, risk stratification, and management of a patient. Several studies show chest imaging can be

used in the diagnosis of COVID-19 as well as it help to gauge the outcome of a patient by using some severity scoring methods.[7] Chest imaging is being routinely done in the form of a chest x-ray and CT scan. Common radiological findings in COVID-19 include peripheral, patchy, or bilateral ground-glass opacities with lower lobe predominance. Consolidation is also seen. Less commonly encountered imaging findings are reverse halo sign, lymphadenopathy, pleural effusion, tree-in-bud nodules, and cystic changes.[6] The value of an imaging test relates to the generation of result that is clinically actionable either for establishing a diagnosis or for guiding management, triage, or therapy. On the other hand, value is diminished by cost, risk of radiation exposure to the patient, risk of cross transmission of COVID-19 infection, use of PPE, and needs for cleaning and downtime of radiology room etc. in resource- constrained environment. Recently COVID-19 radiological literature focuses primarily on CT scan findings which are more sensitive (about 97%) and specific than chest x-ray for early parenchymal lung disease, disease progression, and alternative diagnosis including acute heart failure from COVID-19 myocardial injury, pulmonary embolus.[1] CT scan is more sensitive than chest x-ray for predicting severity and monitoring the progression of the disease.[8] But it has to be remembered that performing CT scan is not easy during this pandemic situation, because it is costly, not easily available, need additional scanner disinfection procedure to prevent cross-infection. Moreover, it causes excessive radiation exposure especially to young a patient.[9]

So considering the above limitations during this pandemic situation we can use chest x-ray though its sensitivity (67.1%) and specificity is below than CT scan.[9] The utility of CXR in predicting clinical outcomes has been investigated in the severe acute respiratory syndrome (SARS) coronavirus as well as in a variety of other types of pneumonia, very few studies have assessed the prognostic value of a CXR in COVID-19 patients.[10] Recently some studies use severity scoring methods in chest x-ray by which outcome of a patient can be predicted.[7] So, it will help us in early better management of a patient as well as saving lives in resource-constrained environment.

So, the aim of the study is to analyze the chest x-ray severity scoring system and its association with outcome in young adult patients with COVID-19. The outcome of interest includes hospitalization, sepsis, ICU admission, and death.

Materials and method

This was a cross-sectional study carried out from September 15 to December 31 2020 in the COVID unit of BSMMU. This study was approved by the ethical review board.

Data collection procedure:

Before data collection, a data collection sheet was developed and piloting was done by four patients, then data collection sheet was modified. Data was collected in a pre-tested data collection sheet. Patients between the ages of 18-40 years with COVID-19 disease confirmed by RT-PCR presented in the triage room of BSMMU were identified. Among them who had symptoms for seven days or more were enrolled in the study. Patients with pre-existing lung and cardiac disease were excluded. After taking an informed consent a detailed history followed by necessary physical examination was done. Baseline laboratory data obtained within 24 hour of presentation, including CBC, D-dimer, CRP, S. ferritin, SGPT, S.creatinine. Oxygen saturation was measured by pulse oximeter and recorded. Then chest x-ray postero-anterior view was done in radiology department of BSMMU. Each patient's chest x-ray was examined by a radiologist and a pulmonologist with experience of 10 years who were blinded about the symptoms of patient followed by joint consensus.

Radiological scoring

Radiological scoring was done by using a scoring system adapted from (Toussie et al. 2020), and (Cohen et al. 2020) based on two type of scores (parameters).[7,11]

The extent of lung involvement and degree of lung opacities:

1. Chest x-ray divided into 3 zones per lung, a severity score was assigned based on the presence (score 1) or absence (score 0) of opacity in each zone. Score 1 for each lung zone. Total 6 zones, so maximum score was 6 and minimum score was 0

2. The degree of opacity for each lung was scored as
   0= no opacity
   1 = ground glass opacity
   2= consolidation
   3= white-out
   Maximum score was 6 (3×2) and minimum score was 0
   Total severity score was maximum 12 (6+6) and minimum 0.

The radiographic features were diagnosed according to the Fleischner society glossary: Ground-glass opacity (GGO) was defined as an increase opacities of the lung which does not obscure the blood vessels and airways. Consolidation was defined as homogenous opacities that obscures the blood vessels and airway walls. Whiteout was defined as total opacification of one side of the lung.[12]

Zonal distribution: The upper zone extends from the apex to the superior hilar markings, the middle zone extends from the superior hilar markings to the inferior hilar markings, and the lower zone extends from the inferior hilar markings to the costophrenic sulcus.[13]

Then each patient was followed-up after 20 days from the first presentation to the triage room to see the outcome.

Data Analysis:

After the collection of data, all data were checked, tabulated, and coded. Then data were entered into the computer and statistical analysis was done using the computer program SPSS (Statistical Package for the social sciences) version 22. The numerical data obtained from the study were analyzed and the significance of difference was estimated by using a statistical method. Continuous variables were expressed as mean value± standard deviation and compared using the student t-test. Categorical variables were expressed as count and percentages and compared using the chi-square test. P values less than 0.05 were considered statistically significant. Data presentation: Different tables, graphs, charts, diagrams, etc. were used to illustrate and publish the result of the study.

Results

A total of 100 patients were selected by consecutive sampling. The age limit was 18-40 years. The mean ± SD of age (in years) was found as 34.95 ± 5.12. Most patients were male, 63% and female was 37%. Though we included young patients in our study, diabetes and hypertension were found in 23% and 22% cases respectively. The maximum patient was found non-smoker,(84/100, 84%).Smoker was 16%. The most common symptom was fever (99/100, 99%) followed by cough (89/100, 89%) and shortness of breath (74/100, 74%). Common non-respiratory symptoms were loss of taste (74/100, 74%) and loss of smell (58/100,58%), and diarrhea (25/100, 25%).

Table-I

Characteristics of sample

Characteristic	Frequency(n)	Percentage (%)
Age (years)		
21-25	8	8
26-30	11	11
31-35	28	28
36-40	53	53
Mean ± SD	34.95 ± 5.12	
Sex		
Male	63	63
Female	37	37
Co-morbid condition		
Diabetes mellitus	23	23
Hypertension	22	22
Smoking status		
Smoker	16	16
Non-smoker	84	84

Chest x-ray features

Chest x-ray was done within 24 hours of presentation. 17% chest x-ray demonstrated no abnormalities, though patients were symptomatic. 83% showed abnormalities among them ground-glass opacity was the commonest radiological features,(64%,) next was consolidation, (27%) and 8% patients had both ground glass opacity and consolidation. The lower lung was most commonly affected (83%) followed by the middle zone (65%). Involvement of upper zone was present in 9% of cases. Bilateral lung involvements were common (71%).

The maximum radiological score was found 10 and only 2 patients had this score.17 patients had score 0. Maximum patients had a score between 4 to 8.

Table-II

Frequency of radiological score of patient

Radiological score	Frequency (n)	Percentage (%)
0	17	17.0
2	8	7.0
3	4	4.0
4	15	15.0
5	20	20.0
6	14	14.0
7	10	10.0
8	7	7.0
9	3	3.0
10	2	2.0
11	0	0.0
12	0	0.0

Outcome of patients

27 patients out of 100 did not need hospital admission. Total 73 patients admitted in hospital among them sepsis developed in 29 patients, 10 patients needed ICU support among them 2 patients got mechanical ventilation. 1 patient was dead.

Association of the radiological score with patient's outcome

Maximum patients who needed hospitalization had a radiological score ≥4. (67/73, 91.8%), and those who had score < 4, only 6 patients out of 73 (8.2%) needed hospital admission.

Total 29 patients developed sepsis among them 27 patients had a radiological score ≥ 5 (27/29,93.1) only 2 (6.9%) patients had score < 5.

Total 10 patients needed ICU support and all of them had radiological score ≥7. 90 patients did not need ICU support among them 12 patients had score ≥7 (12/90,13.3%) and 78 patients had radiological score <7 (78/90,86.7%)

Table-III

Association of the radiological score with patient's outcome

Radiological score	Outcome		Total	p-value
	Hospitalization	Home management		
≥4.0	67 (91.8)	4 (14.8)	71 (71.0)	<0.001
<4.0	6 (8.2)	23 (85.2)	29 (29.0)	
Total	73 (100.0)	27 (100.0)	100 (100.0)	
	Sepsis	Other than sepsis		
≥ 5	27 (93.1)	29 (40.8)	56 (56.0)	<0.001
< 5	2 (6.9)	42 (59.2)	44 (44.0)	
Total	29 (100.0)	71 (100.0)	100 (100.0)	
	ICU support	Other than ICU support		
≥7	10 (100.0)	12 (13.3)	22 (22.0)	<0.001
<7	0 (0.0)	78 (86.7)	78 (78.0)	
Total	10 (100.0)	90 (100.0)	100 (100.0)	

The sensitivity of radiological scoring in predicting outcome was very high, for hospitalization, sepsis, and ICU support it was 91.8%, 93.1%, and 100% respectively. Specificity was 85.2%% for hospitalization. But for sepsis and ICU admission it was 59.2% and 86.7%. The positive predictive value was high for hospitalization 94.4%. The accuracy of radiological scoring for predicting outcomes was 90.0% for hospitalization, 69.0% for sepsis, and 88% for ICU support.

Discussion

The ongoing COVID-19 pandemic has placed an unprecedented burden on the health system. It has highlighted the need for prompt diagnostic and prognostic strategies to optimize patient management, especially when the available resources are limited or overwhelmed.[10] The COVID-19 disease is a highly contagious infection and it affected all age groups. Disease severity and mortality are high in the older age group, because of multiple comorbidities, pre-existing lung and cardiac disease.[14] So, chest radiograph interpretation can often be confounded by underlying comorbid condition, such as heart failure or chronic lung disease.[11] Young adult has comparatively less risk to developed severe disease because of the less co-morbid condition and this age group contributes a large portion of the population. So we choose a young adult group for our study.

A few studies have examined the value of chest x-ray to predict COVID-19 outcomes.[10] In April 2020 Toussie et al. used a chest x-ray severity score to predict the risk for hospitalization and intubation in young and middle-aged patients with COVID-19.[11] In early May 2020 Borghesi et al. introduced the Brixia score, on an experimental chest x-ray scoring system for quantifying lung abnormalities in COVID-19 pneumonia, high Brixia score values have been found to predict in-hospital mortality for COVID-19.[15] Both studies used severity score on extension of lung involvement but in our study, we used extension of lung involvement as well as type of radiological lesion in making severity score.

This cross-sectional study explores the value of chest x-ray severity score in predicting the outcome of a patient with COVID-19.Our study population was mainly composed of patients having symptoms 7 days or more. The median number of days from symptoms onset to presentation to triage room was 10 days. The previous study showed highest radiological severity was approximately 6-11 days after the onset of disease symptoms.[10] So in our study, the proportion of normal chest x-rays were lower (17/100, 17%) than those reported in Palwa et al. where patients presented earlier in the course of their disease and had minimal symptoms of the disease.[16] 83% of patients had an abnormal chest x-ray in our study which is consistent with the findings of a previous study done by Baratella et al. They found 95% of patients had abnormal chest x-ray at baseline.[17]

Like previous study male patients were more than female (63% vs 37%) in our study and male patients showing a high radiological score and high rate of hospitalization, development of sepsis, and ICU admission. The most common symptoms among our patients were fever (99%) followed by cough (89%), shortness of breath (74%), which are the common presentation among patients with COVID -19 disease worldwide.[13]

Diabetes mellitus and hypertension were common co-morbid conditions among our study population and it increased the

risk of hospitalization, sepsis, and ICU admission. Diabetic patients had high radiological score than hypertensive patients. In our study two patient had malignancy and both had high radiological (score ≥ 6).

The most common chest x-ray finding in our study population was ground-glass opacity followed by consolidation (64% vs 27%). Bilateral (71%), lower zone (83%) involvements were common. Left lower lung involvement was more common than right lower lung (75% vs 68%). Our findings are in consensus with a previous study on the spectrum of chest x-ray findings in the COVID-19 positive patient.[16] We observed that patients who had consolidation in their chest x-ray they developed sepsis and they needed ICU support more in comparison to patients who had ground glass opacity in chest x-ray. Our observations are in consensus with the findings of previous study done by Bulbi et al. they also found consolidation as a sign of advanced pneumonia.[10]

In our study, we utilize a semi-quantitative scoring system for zonal assessment of each lung involved by the disease process. We used a severity score for the quantification of lung involvement. We found a significant statistical correlation between radiological score and patient outcomes. Radiological score more than 4 correlated with increased hospitalization, severity score 5 or more associated with increased risk of being developed sepsis, and radiological score 7 or more associated with increased risk of being admitted to ICU. Patients with opacities in at least 2 lung zones were more likely to require hospitalization. These findings are consistent with the results of Toussie et al.[11]

In our study chest x-ray severity score showed the positive predictive value for hospitalization was 94.4%. The sensitivity of radiological score was highest for ICU support (100%,) for sepsis it was 93.1% and for hospitalization sensitivity of chest x-ray was 92.8%.

Outcome was assessed after 20 days of radiological scoring so the outcome did not bias the radiological scoring. And radiological scoring was done by two physicians who are blinded about patients' symptoms and outcome so there was less chance of biasness in radiological scoring and this is the strength of this study

In summary chest x-ray has not being recommended for diagnosis of COVID-19 but it can be used as a tool for risk stratification of patients and decision making regarding hospitalization and close monitoring of specific patients in COVID-19 pneumonia.

Conclusion

In our experience chest x-ray after a certain period (after 7 days) had good sensitivity and specificity for predicting outcome. Chest severity score can be used in low resource conditions in emergency settings as a quantitative method to predict the risk of hospitalization or development of sepsis or need for ICU support. The result of our study could help the physician to identify the high-risk patient and allow them for taking proper steps of timely management to prevent death. Our opinion is that radiological imaging should be always associated with clinical and laboratory parameters for monitoring the disease course. Every country has its own protocol for the management of the patient with the COVID-19 disease. But the safety of health professionals and proper use of diagnostic resources during this pandemic situation should be kept in mind.

Ethical consideration

Before starting this study, the research protocol was submitted to the institutional review board of BSMMU, Dhaka. Voluntary informed written consent was taken from every patient after an explanation of the procedure and purpose of the study. Every patient was given the right to participate or refuse to participate. Every patient had the right to withdraw from the study at any time without compromising their medical care. The patient´s privacy was ensured and the patient´s information was not disclosed to anyone. This study did not cause any harm to the patient and was not affect the quality of their treatment. The patient and /or responsible family member was informed about the potential risk of a chest x-ray. No drug or placebos were used for this study

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