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Original Article

Value of baseline radiograph for COVID-19 infected patients

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Abstract

Introduction: *A cluster of pneumonia cases of unknown origin was first reported in Wuhan China then the causative pathogen was identified and named severe acute respiratory syndrome coronavirus 2 (SARS-Cov2) and the associated disease was named coronavirus disease 2019 (COVID-19). Chest radiograph has lower sensitivity for the detection of lung abnormalities but it has a role in disease progression and also in the late stages of COVID-19. This study aims to evaluate the value of baseline radiographs in COVID-19-infected patients.*

Method: *This is a retrospective study of COVID-19 patients with RT-PCR confirmation who were admitted to Eka Kotebe General Hospital and had baseline chest x-ray between April and May 2020. Baseline chest x-ray of all patients who have confirmed COVID-19 infection was reviewed and analyzed.*

Result: *The study included 355 patients, 224 (63.1%) were male and 131 (36.9%) were female. Patient age ranged from 4 - 82 years with a mean age of 35. Two hundred twelve patients were symptomatic; the rest 143 were asymptomatic. Of the 355 baseline CXR, only 60 (16.9%) had abnormal radiographs and the rest 295 (83.1%) had normal radiographs. A combination of interstitial changes and GGO were the predominant descriptive finding accounting for 33.3% .*

Conclusion: *Even if chest radiographs are important in the workup of patients with COVID-19 infection, the use of baseline radiographs in COVID-19 infection should not be a routine practice. Disease severity and timing of imaging appear to impact the rates of normal baseline imaging.*

Keywords: Baseline, COVID-19, Chest Radiograph
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Introduction

Coronavirus is enveloped RNA virus belonging to the family of coronaviruses and is broadly distributed among humans and other mammals and causes respiratory, enteric, hepatic, and neurologic disease(1) . The two beta coronaviruses, severe acute respiratory syndrome (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV) have caused more than 10,000 cumulative cases in the past two decades with mortality rates of 10% for SARS-CoV and 37% for MERS-CoV (2).

A cluster of pneumonia cases of unknown origin was first reported in Wuhan city china on 31 December 2019 and on January 7, 2020, the causative pathogen was identified as a novel coronavirus(3). This virus was named severe acute respiratory syndrome coronavirus 2 (SARS-CoV2) and the associated disease was named coronavirus disease 2019 (COVID-19). Since December 2019, COVID-19 has rapidly spread from Wuhan to other parts of China and throughout the world, and on March 11, 2020 COVID-19 was declared a pandemic by WHO(4).

On March 13, 2020, the first COVID-19-infected person in Ethiopia was confirmed (5). The most common symptoms associated with COVID-19 infection are fever (accounting for 98% of the symptoms), myalgia or fatigue, and shortness of breath. Less common symptoms include sputum production, headache, haemoptysis, sore throat, chest pain, and diarrhea(2). The severity of the disease can range from asymptomatic and mild cases to acute respiratory distress syndrome and death (6).

According to Fleischner society, a multinational consensus statement, imaging is indicated for patients with COVID-19 with evidence of worsening of respiratory status and for patients with moderate to severe features of COVID-19 regardless of the COVID-19 test result. Imaging is not indicated for patients with mild features

of COVID-19 unless they are at risk for disease progression and it is not indicated as a screening test for COVID-19 in asymptomatic individuals (6). COVID-19 primarily affects lung parenchyma and it has a high rate of human-to-human transmission and the number of confirmed cases is increasing exponentially.

The diagnosis of the COVID-19 is confirmed by a positive reverse transcriptase-polymerase chain reaction (RT PCR) nasopharyngeal or oropharyngeal swab test. This test is highly specific however, the sensitivity is reportedly as low as 60-70%. The high rate of false-negative results particularly early in disease time courses and inconsistent availability of testing means that a systematic approach to diagnosis must be employed including radiological imaging (7). Baseline chest X-ray has lower sensitivity compared to initial RT-PCR but because of inconsistent availability of RT-PCR and long turnaround time, CXR can aid in the diagnosis of COVID-19.

The most common radiographic features in confirmed COVID-19 patients are peripheral rounded ground-glass opacity, consolidation and pulmonary nodules. The distribution of the lung changes was more common in lower zones and bilateral (8). The chest x-ray findings in these patients frequently showed bilateral lower zone consolidation which peaked at 10-12 days from onset (8)

Disease severity and timing of imaging appear to impact the rates of normal baseline imaging. In a non -severe disease, up to 18% of patients have a normal initial CXR or CT but only 3% in severe disease (9)

CT has higher sensitivity reaching about 97% especially in detecting early disease and most studies regarding the characteristics pattern of imaging findings have focused predominantly on the use of CT imaging(10).

Although chest radiograph is not considered to be sensitive for the detection of lung abnormalities especially in the early stage of the disease, it has a role in the disease progression and also in the late stages of COVID-19(11).

Chest X-ray is a relatively inexpensive and widely available diagnostic modality and in addition to the clinical findings, appearance on chest X-ray can aid in assessing the severity of illness and also guide in management. In the institution where this study was conducted, routine CXR was the routine practice for all patients who have proved COVID-19 pneumonia irrespective of the clinical stages of the disease. So, we would like to evaluate the value of routine CXR for COVID-19 patients. This study will evaluate the value of baseline radiograph in patients with COVID-19 infection.

Methodology

Research setting

This study was conducted at Eka Kotebe general hospital, which is under the auspices of St. Amanuel Mental Hospital and has been inaugurated in October 2019. Since March 2020 this hospital has been assigned as the first treatment centre for COVID-19 patients in Addis Ababa, Ethiopia. During the initial phases of COVID-19 infection in Ethiopia, when this data was collected, all patients who are positive for RT-PCR were admitted to this hospital irrespective of their clinical condition.

Study design and study population

This study is an institutional-based retrospective cross-sectional study done on chest radiographic images of all RT-PCR confirmed COVID-19 infected patients who were hospitalized in Eka Kotebe general hospital in the period from April to May 2020. All COVID-19 confirmed patients who fulfill the inclusion criteria and have chest radiographic imaging done at the Eka Kotebe general hospital during the stated study period were included in this study.

Sampling size determination

The sample size was calculated using Daniel's formula for a cross sectional study, where P=30% (from previous similar studies (12)); d=5% (margin of error); and Z=standard score, corresponding to 1.96, with a 95% confidence interval. This would give a sample size of 323. To compensate for non-response and incompleteness, 10% was added, giving a total of 355 study participants.

$N= Z^2 P (1-P)/ d^2$

Where:

N = total number of subjects required in the population

Z = a standardized normal deviate value that corresponds to a 95% level of confidence equal to 1.96

P = estimate of the prevalence of CXR abnormalities, 30 %

d = margin of error, which corresponds to the level of precision of results desired

$$N = \frac{(1.96)^2 \times 0.3x(1-0.3)}{(0.05)^2} = 322.69$$

Non-response rate = 10% of N = 10/100 (323) = 32.3. Total sample size = 323 + 32.3 = 355

Data collection procedure

Data was collected using a structured questionnaire developed which contains patient age and sex, initial clinical evaluation during patient admission to the institution, and the first CXR taken on admission. The radiographs then were reviewed by three consultant radiologists who have more than ten years of experience and imaging data were filled separately and images that had differences in the findings were again reviewed with the radiologists together and a consensus was made on the findings and questionnaire were filled accordingly.

All COVID-19 confirmed patients in Eka Kotebe general hospital during the stated study period are eligible for this study. All COVID-19 confirmed patients who had chest radiographic images in Eka Ko-

tebe general hospital during the stated study period are included in this study. Patients with confirmed COVID-19 infection in Eka Kotebe general hospital who don't have chest radiographic images were automatically excluded from the study.

Data processing and analysis

The data was checked for clarity and completeness. Data were analysed using nonparametric statistical methods with the help of the SPSS software package. Then summarization and comparison of data were done.

To evaluate the clarity of the questionnaire, validity of the instruments, and after the pre-test, the findings and observations obtained were used to modify the questionnaire and the data collection process accordingly.

Operational Definitions

Clinical severity scoring

Asymptomatic or pre-symptomatic infection: Individuals who test positive for SARS-CoV-2 using a virologic test but who have no symptoms that are consistent with COVID-19.

Mild illness: Individuals who have any of the various signs and symptoms of COVID-19 (e.g., fever, cough, sore throat, malaise, headache, muscle pain, nausea, vomiting, diarrhea, loss of taste and smell) but who do not have shortness of breath, dyspnoea, or abnormal chest imaging.

Moderate illness: Individuals who show evidence of lower respiratory disease during clinical assessment or imaging and who have an oxygen saturation measured by pulse oximetry (SpO2) ≥94% on room air at sea level.

Severe illness: Individuals who have SpO2 <94% on room air at sea level, a ratio of arterial partial pressure of oxygen to fraction of inspired oxygen (PaO2/FiO2) <300 mm Hg, a respiratory rate >30 breaths/min, or lung infiltrates >50%.

Critical illness: Individuals who have respiratory failure, septic shock, and/or multiple organ dysfunction.

Chest X-ray severity scoring system

Each lung is divided into three zones. Upper level: above the inferior wall of the aortic arch, middle level: below the inferior wall of the aortic arch and above the inferior wall of the right inferior pulmonary vein (hilar structures) and the lower level is below the inferior wall of the right inferior pulmonary vein (lung bases) then score (from 0-3 points) is assigned to each zone based on the detected lung abnormalities. 0- no lung abnormalities, 1- interstitial infiltrates, 2- interstitial and alveolar infiltrates (interstitial predominance) and 3- interstitial and alveolar infiltrates (alveolar predominance). The overall score is the sum of points from all the zones which ranges from 0-18 points and chest findings were reviewed accordingly and severity categorized as mild, moderate and severe based on sum of scores.

Linear (interstitial) opacities: described as horizontal white lines or reticular changes (15).

Ground glass opacities: described when lung markings are partially obscured by increased whiteness (15).

Consolidation: described when the lung markings are completely lost due to whiteness

Ethical considerations

No patient identifiers were used in data collection or analysis and imaging data were collected from the image store. Any piece of information was kept confidential by keeping the anonymity of the study subjects. Permission was given from the institution and ethical clearance was obtained from the department research and ethics committee.

Result

The study included 355 patients; among them, 224 (63.1%) were male and 131 (36.9%) were female. The mean age was 35 ± 16 years with the age range of 4 to 82 years old (Figure 1).

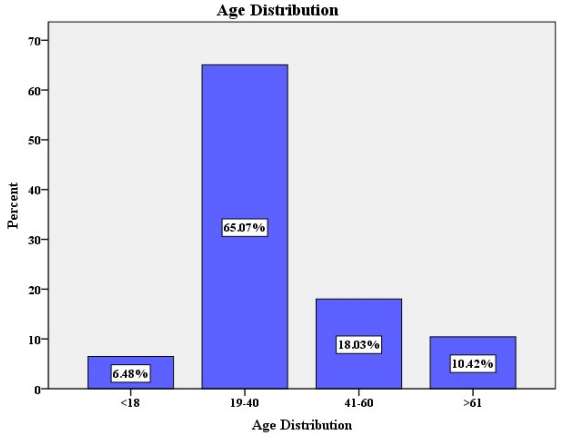

Figure 1: Age distribution of patients with COVID-19, Eka Kotebe, General Hospital, Ethiopia , 2020

Among the total of 355 patients, 143 (40.3%) were asymptomatic and 212 (59.7%) were symptomatic. From 212 patients who were symptomatic 191 (90.1%) had mild symptoms, 6 (2.8%) had moderate symptoms and 15 (7.1%) showed severe symptoms.

Among 212 symptomatic patients 43 (20.3%) had abnormal chest X-rays. Among the 191 patients with mild clinical symptoms 30 (15.7%) had abnormal radiograph but from the 15 patients with severe clinical symptoms 12 (80%) had abnormal radiograph. From the 143 asymptomatic patients 17 (11.9%) had abnormal chest X-rays. (figure 2)

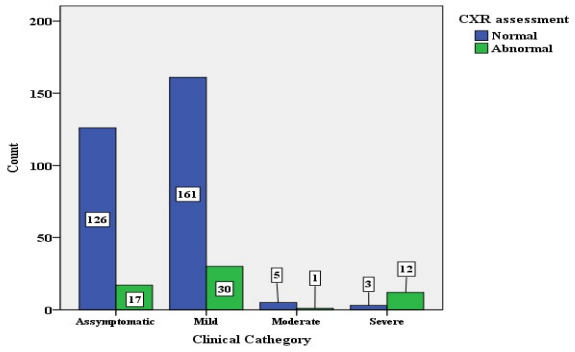

Figure 2: Clinical category based on chest radiographic assessment, Eka Kotebe, General Hospital, Ethiopia 2020

Of 355 patients only 60 (16.9%) showed abnormal chest radiograph and the rest 295 (83.1%) had normal chest radiograph. From 60 patients who showed chest x-ray abnormality; 40 (66.7%) showed a mild abnormality, 8 (13.3%) showed moderate abnormality and 12 (20%) showed severe abnormality.

As shown from figure [3] below, from the 40 patients who showed mild severity on chest radiograph, the majority of patients are in the age range of 41 and 60 years, while from 12 patients who showed severe chest radiograph abnormality the majority of the patients are above 61 years old.

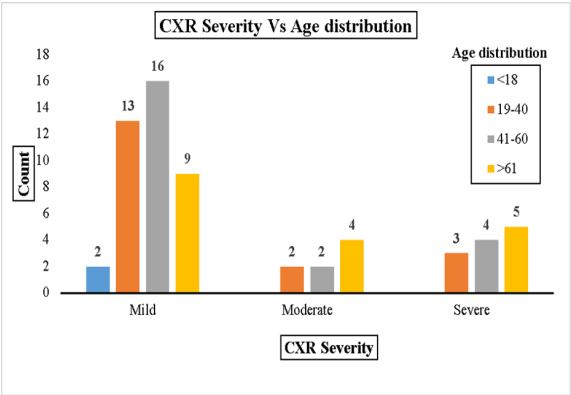

Figure 3: CXR severity with age distribution, Eka Kotebe, General Hospital, Ethiopia 2020

Out of 40 patients who showed a mild radiographic abnormality, 27 (67.5%) patients had a severity score range of 0-5 and 13 (32.5%) patients had a severity score range of 6-11. From 8 patients who showed a moderate abnormality, 6 (75%) patients had a severity score range of 6-11, and 2 (25%) patients had a severity score of ≥ 12. From the total of 12 patients who showed severe chest x-ray abnormalities, 1 (8.3%) patient had a severity score range of 6-11 while the rest 11 (91.7%) patients had a severity score of ≥ 12.

A combination of linear interstitial changes and GGO were the predominant radiographic finding accounting for 20 (33.3%), followed by an interstitial change which accounts for 11 (18.3%) of the total 60 patients with abnormal chest X-ray. Ground glass opacity alone accounts for 10 (16.7%) and consolidation alone was the least predominant finding accounting for 3 (5%) of the total 60 patients with abnormal chest X-rays. (figure 4)

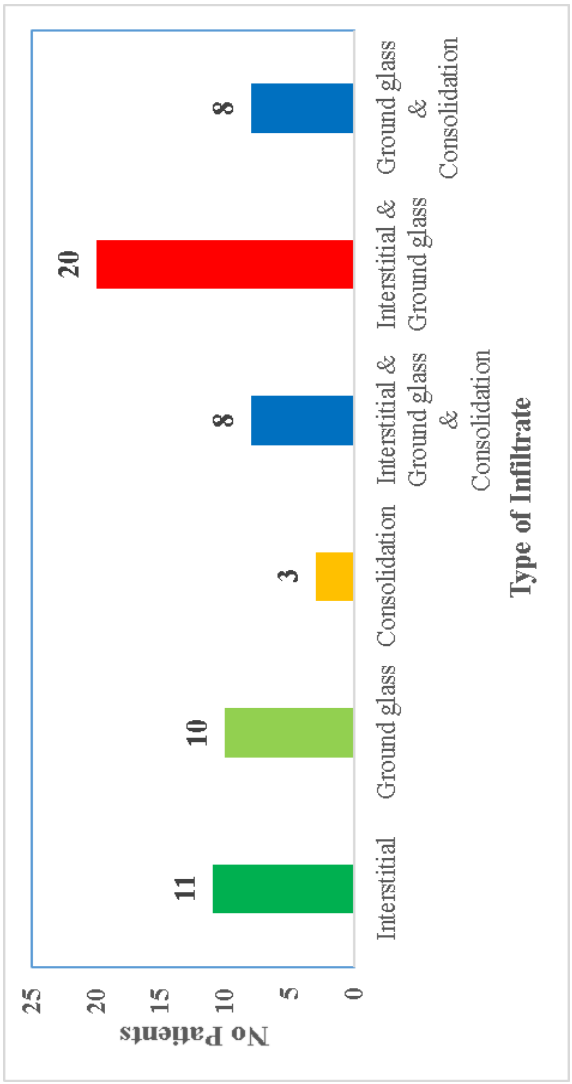

Figure 4 :Frequency of patients for types of infiltrate, Eka Kotebe, General Hospital, Ethiopia

A combination of lower and middle lung location is the predominant chest radiograph location account ing for 22/60 patients (36.7%). Which are multifocal in 86.7% and bilateral in 83.3%. (Table 1)

Table 1: patterns of CXR findings in COVID-19 patients, Eka Kotebe, General Hospital, Ethiopia , 2020

Radiologic Properties	Categories	Frequency	Percent
Location abnormality	Lower	16	26.7
	Middle	3	5.0
	Diffuse	15	25.0
	Lower & Middle	22	36.7
	Middle & Upper	3	5.0
	Lower & Upper	1	1.7
Focality of findings	Unifocal	8	13.3
	Multifocal	52	86.7
Laterality of findings	Unilateral	10	16.7
	Bilateral	50	83.3
Centrality if findings	Peripheral	45	75
	Central	3	5
	Both	12	20
Other associated findings	None	346	97.5
	Effusion	1	0.3
	Mediastinal abnormality	2	0.6
	Dilated main pulmonary artery	1	0.3
	Basal atelectasis bilateral	2	0.6
	Left lower sub segmental atelectasis	1	0.3
	Left basal atelectasis and elevated left hemi diaphragm	1	0.3
	Effusion & mediastinal abnormality	1	0.3

Discussion

This research describes the common radiographic features of 355 COVID-19 infected patients. From the baseline radiographs of these patients, only 60 (16.9%) patients showed abnormal chest radiographs and the rest 295 (83.1%) had normal radiographs. The majority of patients 212/355 (59.7%) were symptomatic presenting mainly with mild symptoms (90.1%), the rest 143/355 (40.3%) were asymptomatic. The major radiographic abnormalities were interstitial and ground-glass opacity which were mainly located in the middle and lower lobe and also predominantly bilateral and peripheral.

Unlike other similar studies which showed the rate of normal chest radiographs ranging from 5.6% to 58.3% (8, 12), our study showed the great majority of baseline radiographs (83.1%) to be normal. The reason can be explained by the fact that most patients were asymptomatic and among those symptomatic cases, most patients (90.1%) had mild symptoms. Another explanation could be that during the period when this data was collected, all patients who were positive for RT-PCR for COVID-19 were admitted to the hospital irrespective of their clinical status. The rate of abnormal chest radiographs is higher in those who have severe clinical symptoms as shown in our study which revealed 80% of radiographs with severe clinical symptoms were abnormal. Even if radiographs are important in the diagnosis of COVID-19 pneumonia and evaluate other mimickers of pneumonia, it should not be used as a screening for COVID-19 infection, and baseline radiographs have no value in asymptomatic patients' and for those having mild and moderate clinical symptoms. The findings of normal chest radiograph at baseline imaging are not a guarantee for subsequent development of abnormalities on follow-up imaging because chest radiograph severity scores will change over time (9). So, follow-up chest radiographs in patients who have normal baseline radiographs can be done if there is clinical disease progression (6).

In the initial phase of the pandemic, including the scenario in our study setting, chest radiographs were routinely used in patients presented with ambulatory care settings but more than half of the radiographs were found to be normal and only 5% of abnormal radiographs showed severe disease(13, 14). Due to the low sensitivity of radiographs for patients with COVID-19 infection (14), clinical evaluation and screening for patients with COVID-19 infection is important to avoid unnecessary radiographs.

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Despite the variable radiographic features described in the literature, the predominant radiographic findings reported and also shown in this study are interstitial changes and ground-glass opacities either alone or in combinations. Bilateralism of the findings which are predominantly in the lower lobes and peripheral lung shown in this study was also features reported in most literature. (8, 13-15). Consolidations were the least radiographic findings in our study which is also consistent with findings in other works of literature (15).

The frequency and severity of radiographic findings also depend on the clinical severity score (8). In our study, out of 40 patients who showed mild chest radiographic majority (67.5%) had a severity score range of 0 – 5, and out of a total of 12 patients who showed severe chest radiographic abnormality , 91.7% had severity scores of greater than 12.

Conclusion and Recommendation

Even if chest radiographs are important in the workup of patients with COVID-19 infection, the use of baseline radiographs in COVID-19 infection should not be a routine practice. The most common radiographic findings of COVID-19 infection are interstitial findings and ground glass lesions predominantly at bilateral lower lobes in the peripheral lungs.

Limitation

This is a retrospective single centred study.

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