

# Chest X-Ray as a Diagnostic and Prognostic Tool For Covid-19; A Tertiary Care Hospital Based Study

Muhammad Farooq Sattar<sup>1</sup>, Furquana Niaz<sup>2</sup>, Arshad Ali<sup>3</sup>, Nadia Shams<sup>4</sup>, Nayyer ul Islam<sup>5</sup>, Lubna Meraj<sup>6</sup>

## Abstract

**Introduction:** The radiological investigations are not diagnostic of COVID-19 disease but help in management. CT scan is not available worldwide; therefore, an x-ray chest (CXR) is ideal for the assessment of disease severity using a scoring system. This study was conducted to see various CXR findings and the relation of severity with the outcome.

**Materials and Methods:** This study was conducted at Dallah hospital Saudi Arabia. All admitted confirmed cases of COVID-19, above the age of 18-year were included. CXR was done at baseline, after 5-7 days, and after 13-15 days. Patients with previous heart failure, chronic obstructive pulmonary diseases or pulmonary fibrosis, Pregnant and lactating ladies were also excluded.

**Results:** Out of the total of 629 patients 67.6 % were males. There was no statically significant difference in mortality in male to female patients. The mean age was 42.67+15.13 (range 18-83) years. Patients with age more than 50-year were 58.9% and had a severe infection (p=0.041) with high mortality (p=0.045). 63% of patients had abnormal CXR at baseline. The common CXR features detected were consolidation (45%), followed by ground-glass appearance (43%). Only 0.8% of patients had pleural effusion and one patient with pneumothorax. Patients with bilateral lung infiltration were 67.5% and mostly it was in lower zones (63%). The follow-up CXR revealed an increase in severity score which was related to mortality (p<0.001).

**Conclusion:** In COVID-19 infection CXR may be a predictor of severity of disease and monitoring of disease may be done by serial CXR.

**Keywords:** COVID-19, Coronavirus infections, X-ray chest, viral pneumonia.

<sup>1</sup> Consultant Internal Medicine, King Saud Medical City, Riyadh, KSA; <sup>2</sup> Professor & HOD Dermatology, Karachi Institute of Medical Sciences (KIMS), Karachi/ NUMS University, Rawalpindi; <sup>3</sup> Professor of Medicine, Karachi Institute of Medical Sciences (KIMS), Karachi/ NUMS University, Rawalpindi; <sup>4</sup> Professor & HOD Medicine, Rawal Institute of Medical Sciences, Islamabad; <sup>5</sup> Professor & HOD Medicine, Karachi Institute of Medical Sciences (KIMS), Karachi/ NUMS University, Rawalpindi; <sup>6</sup> Associate Professor, Benazir Bhutto Hospital, Rawalpindi. **Correspondence:** Dr. Lubna Meraj, Associate Professor, Benazir Bhutto Hospital, Rawalpindi. **Email:** lubnameraj@gmail.com

**Cite this Article:** Sattar, M.F., Niaz, F., Ali, A., Shams, N., Islam, N., Meraj, L. Chest X-Ray as a Diagnostic and Prognostic Tool For Covid-19; A Tertiary Care Hospital Based Study. International Journal of Rawalpindi Medical College. 30 Jun 2022; 1(1): 29-35.

**Received May 9, 2021; accepted June 14, 2022; published online June 30, 2022**

## 1. Introduction

In December 2019 a respiratory illness with serious consequences was noticed in Wuhan China. The illness was due to the coronavirus which was named severe respiratory distress syndrome coronavirus II (SARS COV II) by the World Health Organization (WHO). Later on, WHO gave the name Coronavirus disease-19 (COVID-19) on 11th February 2020<sup>1</sup> after that it spread the world over and WHO declared it a pandemic disease in March 2020.<sup>2</sup> According to the WHO COVID-19 situation report on 18th October 2021, the total number of confirmed cases worldwide were 240,061,454 with mortality of 4,887,6000.<sup>3</sup> The first case of COVID-19 infection in Saudi Arabia was detected in a person who came from Bahrain on 2nd March 2020.<sup>4</sup> Till October 18, 2021, the confirmed cases were 547,931 all over the Kingdom of Saudi Arabia with 8,763 reported deaths.<sup>5</sup> The initial reports from China revealed that up to 30-40% of patients remained asymptomatic and amongst the

symptomatic patients 81% had mild disease, 14% had severe and 5% had a critical illness. The mortality was higher in severe and critically ill patients.<sup>6</sup>

The gold standard diagnostic test for COVID-19 is real-time PCR for SARS COV II. However certain supporting investigations are advised including the Covid antibodies, inflammatory markers, and radiological investigations. Radiological investigations like X-ray chest or CT scans chest are not confirmatory diagnostic tests but they are invaluable to assess severity, management plan, and prognosis. Although the CT chest is highly sensitive and it is a good investigation for early detection of lung infection but due to difficulty in availability in many centers and the high burden on the radiological department, it is not routinely recommended.

Furthermore, infection control measures need to be taken if a patient is shifted to the radiology department from the isolation ward. Therefore, an x-ray chest is recommended for initial assessment and

further monitoring in symptomatic patients. The portable x-ray chest is the choice in an isolation ward.<sup>7-9</sup> The initial X-ray chest may be normal even in symptomatic patients, therefore follow-up x-ray chests are recommended for deterioration of the disease. The x-ray findings may be variable from consolidation, interstitial involvement, nodular pattern, or ground-glass opacities.<sup>10-11</sup> It's worth mentioning that Chest X-ray may not detect early changes in the lungs; therefore, some centers still prefer to do a CT scan of the chest and keep a separate machine for COVID-19 patients for infection control. But it is not possible and feasible everywhere. Therefore, the American College of Radiology recommended a chest x-ray as the first line.<sup>12-13</sup> Hence, we designed a hospital-based study to study the role of chest x-ray in COVID-19 patients in terms of diagnosis, management plan, and prognosis. The objectives of the study were to describe salient X-ray chest findings of COVID-19 infection and to observe the severity of infection by the scoring system; hence the clinician may have a better idea about lung involvement in COVID-19 infection.

## 2. Materials & Methods

This hospital-based study was done at Dallah Hospital from May 2020 to February 2021. Dallah hospital is a fully equipped tertiary health care center in Riyadh, Saudi Arabia. The approval from the ethical committee was taken (No. ERB028/20) and consent from patients was taken on a special consent form.

All the admitted patients above the age of 18 with confirmed real-time PCR were included in the study. Pregnant and lactating ladies were excluded. Patients with previous heart failure, chronic obstructive pulmonary diseases, or pulmonary fibrosis were also excluded to avoid the confounding effect on the outcome.

Demographic data were taken from the triage record of the emergency department (ED). All patients went through laboratory investigations like CBC, LFT, urea, creatinine, sodium, potassium, coagulation profile, C-reactive protein, ESR, ferritin, LDH, D-Dimer, and troponin.

Initial X-ray chest (CXR) done in ED was recorded as the baseline. The 1st follow-up CXR was done after 5-7 days for comparison. The 2nd follow-up CXR was

taken on 13-15 days for the further plan or to see improvement. The nasopharyngeal swab was taken for real-time polymerase chain reaction (RT-PCR) for the COVID-19 virus. The diagnostic kit was used as per international standard for the detection of virus by PCR.<sup>14</sup>

The age was divided into two groups. The first group was with age 18 to 50-year and the second group of aged above 50-year. According to guidelines by the National Institute of Health, these positive COVID-19 cases were divided into four sub-groups; mild, moderate, severe, and critical.<sup>15</sup> Co-morbidities like hypertension, diabetes, cardiac diseases, chronic kidney disease, obesity, dyslipidemia, chronic obstructive pulmonary disease, and asthma were recorded according to the history of patients. The recovered patients were defined who were discharged from the hospital or shifted to general wards without complications of COVID-19 infection. The period between admission date and discharge of expiry date was considered as the total length of stay in the hospital.

Image acquisition was done by two different radiologists who did not know about patients' clinical status and disease severity. The consensus was done and documented for each image. We divided radiological findings as Consolidation, Ground glass opacity, reticular and nodular shadowing. Also, we noted the part of the lung involved like central or peripheral and upper or lower zone involvement. The involvement area was mentioned in percentage in each lung for scoring purposes. The distribution like peripheral infiltrates or hilar infiltrates was noted. The zonal involvement was divided into upper and lower zone also the site like right or left-sided or bilateral were noted.

The disease severity score was done by a scoring system suggested by Warren et al.<sup>16-17</sup> In which the percentage of lung involvement was scored. A score of 4 means more than 75% lung is involved. Score 3 means 50 to 75% involvement, score 2 means 25 to 50% involvement, score 1 means less than 25% involvement and score 0 means no involvement. Therefore, each lung was given a score of 0-4 and the overall score was from 0 to 8.

Statistical analysis was done on SPSS (version 24.0 IBM). Age groups, gender, severity, and co-morbidities were analyzed by chi-square test. The severity score

was compared by student t-test. A P-value of less than 0.05 was considered statistically significant.

### 3. Results

Out of the total 629 patients, 425 (67.6%) were males. There was no difference in the severity of COVID-19 disease or mortality with association to gender. The mean age was 42.67±15.13 years, ranging from 18-83 years. Patients with ages more than 50-year had a severe infection (p=0.41) with high mortality (p=0.045). Mild to moderate infection was more than severe to critical infection (83.9% vs. 12.9%). Diabetes mellitus was the commonest co-morbidity (26.1%) and was associated with disease severity (p=0.032) and mortality (p=0.045). patients with hypertension also had a severe infection (p=0.042) and high mortality (p=0.049).

The CXR was normal in 37% of cases at baseline. Regarding abnormal findings in CXR, the consolidation was seen in 45%, ground glass appearance in 43%, reticular pattern in 9%, and nodular pattern in 2%. Only 5 patients had pleural effusion and one had a pneumothorax. Bilateral lung involvement was more frequently observed than single lung involvement. Furthermore, there was a predominance of peripheral and lower zone infiltration (Table. 2).

At baseline evaluation of severity score, low severity (0-2) was seen in 84.8%, moderate severity (3-5) in 12.9%, and high severity (6-8) in 2.3%. The severity increased in follow-up chest x-rays. The increase in severity score was found to be significantly related to mortality (Table 3).

**Table 1: Demographic features and clinical symptoms in relation with severity of COVID-19 and outcome**

<b>Variables</b>	<b>Total n=629</b>	<b>Mild to moderate n=523</b>	<b>Severe n=106</b>	<b>P-value</b>	<b>Dead n=38</b>	<b>Alive n=591</b>	<b>P-value</b>
<b>Age group</b>							
• < 50 Years	259 (41%)	222(42.5%)	32(30.20%)	0.082	12(31.4%)	245(41.4%)	0.091
• > 50 Years	370 (59%)	301(57.5%)	74(69.80%)	0.041	26(68.6%)	346(58.6%)	0.045
<b>Gender</b>							
• Male	425(67.6%)	339(64.8%)	73(68.80%)	0.098	28(74.2%)	385(65.1%)	0.061
• Female	204(32.4%)	184(35.2%)	33(31.20%)	0.124	10(25.8%)	206(34.9%)	0.089
<b>Comorbids</b>							
• Diabetic	229(26.1%)	158(20%)	71(66%)	0.032	26(74%)	203(24%)	0.045
• Hypertensive	175(19.9%)	130(17%)	45(42%)	0.042	21(60%)	154(18%)	0.05
• Dyslipidemia	202(23%)	171(22%)	31(29%)	0.134	9(26%)	164(18%)	0.281
• Smoker	97(11%)	76(9%)	21(19%)	0.106	2(6%)	95(11%)	0.314
• Obesity	160(18.2%)	134(17%)	26(24%)	0.31	7(20%)	153(18%)	0.241
• IHD	152(17.3%)	141(18%)	11(10%)	0.132	9(25.7%)	143(16.9%)	0.081
• CLD	50(5.7)	38(5%)	12(1%)	0.092	4(11.4%)	46(5.4%)	0.156
• CKD	60(6.8%)	47(6%)	13(12%)	0.082	16(45.7%)	44(5.2%)	0.042
• CVA	28(3.2%)	19(3%)	9(8%)	0.158	3(8.5%)	25(2.9%)	0.256
<b>Disease Severity</b>							
• Mild	373(42.4%)	373(48)	0(0%)	0.01	0(0%)	373(44.1%)	0.01
• Moderate	366(41.6%)	365(47.5%)	1(1%)	0.02	0(0%)	366(43.3%)	0.01
• Severe	105(12%)	35(4.5%)	70(66%)	0.043	4(11.4%)	101(11.9%)	0.091
• Critical	35(4%)	0(0%)	35(33%)	0.015	31(88.5%)	4(0.4%)	0.021

**Table 2: CXR findings and association with severity of disease and outcome**

<i>X ray findings</i>	<i>Total n=629</i>	<i>Mild to moderate n=523</i>	<i>Severe n=106</i>	<i>P- value</i>	<i>Expired n=38</i>	<i>Survived n=591</i>	<i>P- value</i>
<b>At initial presentation</b>							
• <b>Initially normal</b>	233(37%)	229(43.7%)	4(3.7%)	<0.001	2(5%)	231(39%)	0.03
• <b>Initially abnormal</b>	396(63%)	294(56%)	102(96%)	0.04	36(95%)	360(60.9)	0.001
• <b>Initially normal later abnormal</b>	86(13.6%)	83(15.8%)	3(2.8%)	0.06	2(5%)	84(14.2%)	0.12
<b>At 1st follow up</b>							
• <b>Normal at 1st follow up</b>	109(17.4%)	104(19.8%)	5(4.7%)	0.08	01(2.6%)	108(18.2%)	0.07
• <b>Abnormal at 1st follow up</b>	519(82.6%)	418(79.9%)	101(95%)	0.06	37(97%)	482(81.5%)	0.08
<b>At 2nd follow up</b>							
• <b>Normal at 2nd follow up</b>	212(33.7%)	205(39%)	7(6.6%)	0.56	3(7.8%)	209(35.3%)	0.61
• <b>Abnormal at 2nd follow up</b>	417(66.3%)	366(69.9%)	51(48%)	0.09	25(65.7%)	392(66.3%)	0.06
<b>Findings</b>							
• <b>Ground glass</b>	270(43%)	224(42.8%)	46(43.4%)	0.12	16(42%)	254(42.9%)	0.09
• <b>Consolidation</b>	283(45%)	238(45.5%)	45(42.4%)	0.13	17(44.7%)	266(45%)	0.23
• <b>Reticular</b>	57(9%)	48(9.1%)	9(8.4%)	0.09	3(7.8%)	54(9.1%)	0.08
• <b>Nodular</b>	13(2%)	10(1.9%)	3(2.8%)	0.21	2(5%)	11(1.8%)	0.31
• <b>Pleural effusion</b>	5(0.8%)	3(0.6%)	2(1.8%)	0.56	1(2.6%)	4(0.7%)	0.74
• <b>Pneumothorax</b>	1(0.20%)	0	1(0.1%)	0.02	1(2.6%)	0	0.03
• <b>Right lung</b>	99(15.7%)	83(15.8%)	16(15%)	0.45	6(15.7%)	93(15.7%)	0.65
• <b>Left lung</b>	106(16.8%)	89(17%)	17(16%)	0.47	6(15.7%)	100(16.9%)	0.89
• <b>Both lungs</b>	425(67.5%)	357(68.2%)	68(64%)	0.46	25(65.7%)	400(67.6%)	0.59
• <b>Perihilar area</b>	73(11.60%)	61(11.6%)	12(11.3%)	0.56	4(10.5%)	69(11%)	0.78
• <b>Peripheral lung</b>	423(67.2%)	356(68%)	67(63.2%)	0.23	25(65.7%)	398(67.3%)	0.45
• <b>Diffuse</b>	133(21.2%)	112(21.4%)	21(19.8%)	0.35	8(21%)	125(21%)	0.12
• <b>Right upper zone</b>	38(6%)	32(6.1%)	6(5.6%)	0.25	2(5%)	36(6%)	0.12
• <b>Right lower zone</b>	396(63%)	333(63.6%)	63(59.4%)	0.13	23(60.5%)	373(63.1%)	0.15
• <b>Left upper zone</b>	31(5%)	26(4.9%)	5(4.7%)	0.25	2(5%)	29(4.9%)	0.89
• <b>Left lower zone</b>	163(26%)	137(26.1%)	26(24.5%)	0.78	9(23.6%)	154(26%)	0.54

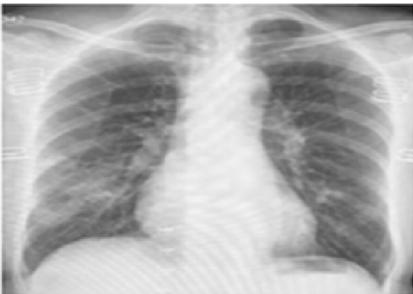
**Table 3: Scoring on Radiological Findings and Its Relation with Outcome**

<i>Score</i>	<i>Baseline</i>	<i>1st follow up</i>	<i>2nd follow up</i>	<i>Survived n=591</i>	<i>Expired n=38</i>	<i>P-value</i>
<b>0</b>	39.1	20.5	38.9	24.6	0	0.45
<b>1</b>	18.8	19.2	25.4	17.1	0	0.81
<b>2</b>	27.4	6.9	7.7	27.2	0	0.17

3	8.8	14.9	8.7	11.4	0	0.18
4	2	13	6.2	7.2	0	0.14
5	2.1	9.6	5.6	5.7	0	0.23
6	1.1	0.3	3.6	4.2	0	0.45
7	0.7	5.6	2.2	2.7	6.3	<0.001
80	0	0	1.7	0	12.5	<0.001



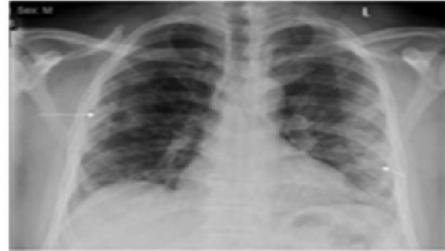
**Figure 1:** Image is taken from male 44 years old patient presented in the emergency department showing bilateral consolidations



**Figure 2:** Image showing glass opacities in a 62 years old smoker patient



**Figure 3:** Image showing bilateral involvement but more on the right side in a 39 years old male patient



**Figure 4:** Image showing interstitial infiltrates in a 38 years old male patient

### Discussion

This study revealed findings of chest X-rays (CXR) in confirmed COVID-19 patients. The abnormal X-ray chest at initial presentation was found in 63%. The positive X-ray findings increased to 83% of the CXR in 1st follow-up, the means the disease may have progressed by the time we get significant abnormal findings in follow-up x-rays. However, on 2nd follow up these abnormalities decreased to 66%, which means that recovery started after 10 days.

The common radiological findings were consolidation i.e., in 45%, followed by ground glass appearance in 43%. The reticular shadowing was found only in 9% whereas nodular in 2%. These findings were almost similar to the findings of a study by Yasin et al in which the consolidation was seen in 81% of patients and ground-glass opacities in 32% of patients.<sup>18</sup>

We found bilateral lung involvement in 67.5% and left-sided lung involvement in 16.8%. Peripheral involvement was more frequent than hilar involvement (67.2% vs. 11.6%). These findings are inconsistent with a study done by Yasin et al. which revealed bilateral lung involvement in 67.5%, which was mostly in peripheral distribution (58.2%).<sup>3,4</sup> Similarly, Wong et al observed consolidation in 47% and ground glass appearance in 33%. They found bilateral lungs involvement in 50% and peripheral involvement in 41%.<sup>7-8</sup>

Similarly, Lomoro et al<sup>19</sup> revealed both lung involvement in 78.1% and consolidation in 46.9%. Jacobi et al<sup>13</sup> concluded that CXR of COVID-19 patients showed a typical reticular pattern, consolidation, and ground-glass opacities. They found more involvement in the peripheral and lower zone.<sup>13</sup> Chen et al<sup>20</sup> also observed both lung involvements in most of the patients with consolidation. On another hand, Ng et al<sup>8</sup> explained that in the early stages of lung disease CXR is not sensitive.

In our study, Only 5(0.8%) patients had pleural effusion, and one patient with pneumothorax. Certain other studies have demonstrated that pleural effusion and pneumothorax are not commonly observed in Covid X-rays.<sup>20</sup> Yasin R et al<sup>18</sup> reported Pneumothorax in 2 cases, which may be due to a ventilator and not by the disease itself.

We did CXR three times for each patient (at presentation, at 1st follow-up, and at 2nd follow-up). As mentioned earlier the percentage of lung involvement was scored from zero to four in each lung, so the minimum score was zero and the maximum was eight collectively.

Borghesi et al<sup>9</sup> reported the Brixia score in which lungs are divided into six zones and infiltration scored from zero to three. Therefore, the minimum score was zero and the maximum score was eighteen. This was a bit complicated scoring system, therefore we did not use it.

This score of severity increased from baseline to 2nd follow-up CXR in our study. At baseline severity score 0-2 was seen in 84.8%, 3-5 in 12.9% while 6-8 in 2.3%. At the first follow-up, the score 0-2 was 56.9%, 3-5 score was 37.5%, and score 6-8 was 5.9%. the 2nd follow-up revealed 0-2 score 72%, 3-5 score 20.5% and 6-8 score up to 7.5%. These results are consistent with the study by Yasin R et al,<sup>18</sup> in which the total severity score changed from zero to eight in baseline and follow-up CXRs. They noticed that most of the cases were mild with a score of 0-2 (65.7%), while only 10.9% of patients with a score of 6-8 had disseminated lung involvement.<sup>18</sup> Similarly, Wong et al reported that 41% had a score of 1-2, 20% had a score of 3-4, and 8% had a score of 5-6, but no one had scored more than 6 in baseline CXR. The severity score increased in follow-up CXR consistent with our findings.<sup>7</sup> The increase in severity score was related to mortality significantly. In our study, disease outcome was related to the severity score. The mean score of  $6.97 \pm 0.81$  for

the dead patients and  $2.05 \pm 1.24$  for the survived patients with high statistical significance ( $p < 0.001$ ). This is similar to the study by Yasin R et al. who observed severity scores of  $6.87 \pm 0.71$  for the patients who expired and  $2.06 \pm 1.84$  for the survivors ( $p < 0.001$ ). Hence, the high radiological severity score is related to mortality. We may conclude that the severity score of CXR can predict the outcome of COVID-19 patients.<sup>18</sup>

The mean age of our patients was  $42.67 \pm 15.13$ -year (range 18-year to 83-year). Almost 58.9% of patients were above the age of 50-year and had a severe infection ( $p = 0.41$ ) with high mortality ( $p = 0.045$ ). Yasin R et al reported that the outcome of the disease was related to an increase in age. The mean age of expired patients was  $51.04 \pm 10.17$  and for recovered patients was  $41.09 \pm 14.14$ .<sup>18</sup>

Regarding co-morbidities, we found diabetes (26.1%) and hypertension (19.9%) related to severe disease and high mortality. The other co-morbidities were less common and not associated with outcome. It is similar to a study by Borghesi et al. in which they found that increased age and co-morbidities like diabetes, hypertension, and cardiovascular diseases were risk factors for severity of disease and fatal outcome.<sup>9</sup>

There are some limitations of our study, first of all, the study is a retrospective hospital-based study but we analyzed the computerized data so there was no recall bias, second the data on management of patients is not included which may affect the outcome, third the co-morbidities had affected on the outcome as mentioned for diabetes and hypertension but there was no comparison of x-ray findings of patients with co-morbidities or without it. Fourth, most of the X-rays taken were AP view and CT scan chest done only in few patients which were not analyzed in this study, so the findings may be missed with AP view of x-ray chest. Although there are limitations the strength of the study is the large sample size which comprises 629 patients and the interpretation of findings and scoring system which may help clinicians in making the decision of management.

## 5. Conclusion

Chest x-rays are a good predictor of the disease severity of COVID-19 infection. The scoring system provides a good understanding of lung involvement. The monitoring of disease by follow-up x-ray may give

clinicians better options for early interventions. We recommend an x-ray chest for all symptomatic patients at baseline and follow-up visits.

#### CONFLICTS OF INTEREST- None

**Acknowledgement:** We acknowledge the hospital administration, medical record department, and IT section for helping in data collection.

**Financial support:** None to report.

**Potential competing interests:** None to report

#### Contributions:

M.F.S, F.N, A.A, N.S, N.I, L.M- Conception of study

M.F.S, F.N, A.A, N.S, N.I, L.M- Experimentation/Study conduction

M.F.S, F.N, A.A, N.S, N.I, L.M-

Analysis/Interpretation/Discussion

M.F.S- Manuscript Writing

M.F.S, F.N, N.S, L.M- Critical Review

M.F.S- Facilitation and Material analysis

#### References

- [1] Lu R, Zhao X, Li J, Niu P, Yang B, Wu H, et al. Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. *Lancet*. 2020 Feb 22;395(10224):565-574. DOI: 10.1016/S0140-6736(20)30251-8.
- [2] World Health Organization. WHO Direct. or General's opening remarks at the media briefing on COVID 19 - 11 March 2020. Geneva, Switzerland: World Health Organization; 2020.
- [3] WHO Coronavirus (COVID-19) Dashboard. Accessed on October 18, 2021. <https://covid19.who.int>
- [4] MOH News. M.O.H. Reports First Case of Coronavirus Infection; 2020. March [Accessed on October 18, 2021] <https://www.moh.gov.sa/en/Ministry/MediaCenter/News/Pages/News-2020-03-02-002.aspx>.
- [5] Saudi Arabia: WHO Coronavirus Disease (COVID-19). <https://covid19.who.int/region/emro/country>
- [6] Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. *JAMA*. 2020 Apr 7;323(13):1239-1242. DOI: 10.1001/jama.2020.2648.
- [7] Wong HYF, Lam HYS, Fong AH, Leung ST, Chin TW, Lo CSY, et al. Frequency and Distribution of Chest Radiographic Findings in Patients Positive for COVID-19. *Radiology*. 2020 Aug;296(2): E72-E78. DOI: 10.1148/radiol.2020201160.
- [8] Ng MY, Lee EYP, Yang J, Yang F, Li X, Wang H, et al. Imaging Profile of the COVID-19 Infection: Radiologic Findings and Literature Review. *Radiol Cardiothorac Imaging*. 2020 Feb 13;2(1):e200034. DOI: 10.1148/ryct.2020200034.
- [9] Borghesi A, Zigliani A, Masciullo R, Golemi S, Maculotti P, Farina D, et al. Radiographic severity index in COVID-19 pneumonia: relationship to age and sex in 783 Italian patients. *Radiol Med*. 2020 May;125(5):461-464. doi: 10.1007/s11547-020-01202-1.
- [10] ACR recommendations for the use of chest radiography and computed tomography (CT) for suspected COVID-19 infection. Updated March 22, 2020. <https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Recommendations-for-Chest-Radiography-and-CT-for-Suspected-COVID19-Infection>
- [11] Bai HX, Hsieh B, Xiong Z, Halsey K, Choi JW, Tran TML, et al. Performance of Radiologists in Differentiating COVID-19 from Non-COVID-19 Viral Pneumonia at Chest CT. *Radiology*. 2020 Aug;296(2): E46-E54. DOI: 10.1148/radiol.2020200823.
- [12] Salehi S, Abedi A, Balakrishnan S, Gholamrezaezhad A. Coronavirus Disease 2019 (COVID-19): A Systematic Review of Imaging Findings in 919 Patients. *AJR Am J Roentgenol*. 2020 Jul;215(1):87-93. DOI: 10.2214/AJR.20.23034.
- [13] Jacobi A, Chung M, Bernheim A, Eber C. Portable chest X-ray in coronavirus disease-19 (COVID-19): A pictorial review. *Clin Imaging*. 2020 Aug;64:35-42. DOI: 10.1016/j.clinimag.2020.04.001.
- [14] Wang W, Xu Y, Gao R, Lu R, Han K, Wu G, Tan W: Detection of SARS-Cov-2 in different types of clinical specimens. *JAMA*. 2020, 323:1843-1844. DOI: 10.1001/jama.2020.3786. doi:10.1001/jama.2020.3786
- [15] COVID-19 treatment guidelines Accessed: October 28, 2021: <https://www.covid19treatmentguidelines.nih.gov/overview/clinical-spectrum/>
- [16] Warren MA, Zhao Z, Koyama T, Bastarache JA, Shaver CM, Semler MW, et al. Severity scoring of lung oedema on the chest radiograph is associated with clinical outcomes in ARDS. *Thorax*. 2018 Sep;73(9):840-846. DOI: 10.1136/thoraxjnl-2017-211280.
- [17] Zhou S, Wang Y, Zhu T, Xia L. CT Features of Coronavirus Disease 2019 (COVID-19) Pneumonia in 62 Patients in Wuhan, China. *AJR Am J Roentgenol*. 2020 Jun;214(6):1287-1294. DOI: 10.2214/AJR.20.22975.
- [18] Yasin R, Gouda W. Chest X-ray findings monitoring COVID-19 disease course and severity. *The Egyptian Journal of Radiology and Nuclear Medicine*. 2020;51(1):193. doi:10.1186/s43055-020-00296-x
- [19] Lomoro P, Verde F, Zerboni F, Simonetti I, Borghi C, Fachinetti C, et al. COVID-19 pneumonia manifestations at the admission on chest ultrasound, radiographs, and CT: single-center study and comprehensive radiologic literature review. *Eur J Radiol Open*. 2020;7:100231. DOI: 10.1016/j.ejro.2020.100231.
- [20] Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet*. 2020 Feb 15;395(10223):507-513. DOI: 10.1016/S0140-6736(20)30211-7.