Chest Radiography Findings of COVID-19 Patients: Differences between the intubated and non-intubated groups

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Abstract:

Objectives: To identify the chest radiography differences at presentation between 2 groups of hospitalized confirmed COVID-19 patients; intubated group compared to the non-intubated group.

Methods: Data of confirmed hospitalized COVID-19 patients at the Royal Hospital, Muscat, Oman were collected retrospectively from March to April 2020. Radiographic and clinical data were collected from the hospital and radiology information systems and compared between 2 groups based on the status of intubation.

Results: 26 patients who were conformed to have COVID-19 by reverse-transcriptase polymerase chain reaction (RT-PCR) test were included in the study. 15/26 were non intubated and 11/26 were intubated. 88.5% were male in overall and 100% in the intubated group. Respiratory symptoms were the commonest presentation (85%) followed by fever (76.9%) with no statistical difference between the 2 groups. There was a statistically significant difference in having diabetes mellitus (p=0.020) in which 8/11 and 4/15 were recorded to have diabetes mellitus in intubated and non-intubated groups respectively. Other comorbidities showed no statistically significant difference. The radiographic analysis re-demonstrates the peripheral lower zone distribution but no statistically significant difference among the 2 groups. There were no differences between the intubated and non-intubated chest radiography in laterality involvement, central and peripheral distribution and type of lesions. However, upper zones involvement was more noted in the intubated group with 10/11 (90.9%) compared to 7/15 (46.6%) in non-intubated cases with p=0.036. There were higher numbers of zone involvement in intubated cases compared to non-intubated cases.

9/11 (81.8%) of intubated patients had 10-12 areas of involvements on chest radiographs as compared to 3/15 (20%) in the non-intubated group. 50% of the cases were discharged home. 3/11 form the intubated group and 10/15 from the non-intubated group. 5 patients died from the intubated group (5/11) versus (3/15) from the non-intubated group. 5 patients are still hospitalized 3/11 and 2/15.

Conclusion: The radiographic findings among intubated and non-intubated hospitalized COVID-19 patients demonstrate differences in the number of zones involved. More upper zone involvement was noted in the intubated group. Male sex and diabetes mellites carry a poorer prognosis and were more associated with the intubated group.

Keywords: COVID-19 Chest Radiography Intubated patients Corona virus Radiology

Introduction

In December 2019, a report of pneumonia of unknown cause starting in Wuhan, China was first delivered to the WHO Country Office. It was then reported to be caused by Covid-19 virus which had genetic sequencing suggestive that it is linked to the SARS group of viruses. [1] The virus outbreak has rapidly spread worldwide. There are now more than 5 millions and 2 hundred thousand patients worldwide affected patients, with a more than 337 thousand cases of related deaths.[2] In Oman, the first affected cases were announced by the ministry of health at the end of March 2020.[3] The current confirmed cases in Oman as of May 25 2020, is 7770 with 36 reported deaths due to COVID-19 infection.

Fever and respiratory symptoms such as cough and shortness of breath were the commonest presentations of the disease.[4-8] Multiple comorbidities were associated with increased risk of hospitalization and poor prognosis. The commonest were; diabetes mellitus, hypertension, and history of smoking.[6, 8-10] Laboratory findings of high neutrophil count and lymphopenia have been associated with the infection. [10-12]

The role of imaging in the diagnostic workup of cases suspected to have COVID-19 has been rising particularly in regions where the reverse-transcriptase polymerase chain reaction (RT-PCR) testing was limited. The wide accessibility to the chest x-ray made it the first imaging modality adopted by many centres at the triage level of COVID-19 patients and in monitoring the admitted group. It was reported that radiological findings in COVID-19 patients were observed at 1-3 weeks from the onset of disease.[13] The main findings on chest radiographs were bilateral peripheral opacities. [13-16]

Imaging using chest radiograph and computed tomography are recommended modalities at the triage room, based on availability. The mobile chest x-ray is the simplest most available modality. Imaging for highly suspicious cases of COVID-19 is recommended to identify the baseline pulmonary status and to assess for any cardiopulmonary abnormalities that may help risk stratification for clinical worsening. In the presence of clinical worsening, imaging including computed tomography is again advised to assess for the progression of COVID19 or the presence of secondary cardiopulmonary abnormalities such as pulmonary embolism, other superimposed bacterial pneumonia, or heart failure that can be related to COVID-19 myocardial injury.[17] In our institution, chest radiography is done at baseline admission and to follow admitted patients and to assess for worsening of symptoms.

In this study, we looked at the initial chest radiograph differences between 2 group of admitted Covid-19 patients; the group of patients required intubation and the admission to ICU to the other group who remained in the normal admission wards. We are looking at any radiographic differences that are associated with worsening of the cases and the requirement of intubation. We also studied the relationship between the clinical and the radiographic findings among the intubated and non-intubated patients.

Methods

Study design and participants:

This was a retrospective study. All patients with confirmed COVID-19 infection, who were admitted to the Royal Hospital, Muscat, were enrolled in the study from the beginning of March to the end of April 2020. COVID-19 infection was confirmed by RT-PCR test for all patients, following our institution protocol. The patient's biographic and laboratory data were accessed from the hospital information system (HIS) and the radiology information system (RIS). Ethical approval was obtained from the ethical committee of the hospital. The requirement for informed patient consent was waived by the ethics committee for this retrospective study.

Image interpretation:

Initial chest radiographs of all the patients were reviewed by 2 experienced cardiothoracic radiologists. Each chest radiograph was divided into 12 segments. The right (R) and left (L) lungs were divided into 3 horizontal zones (Z): upper (U), middle (M) and lower (L) zones. Each lung is then subdivided into 2 vertical zones, peripheral (P) and central (C). The results are 12 areas/zones (Fig.1). The 12 areas were labelled: P-RUZ, C-RUZ, P-RMZ, C-RMZ, P-RLZ, C-RLZ, P-LUZ, C-LUZ, P-LMZ, C-LMZ, P-LLZ, C-LLZ. The presence and absence of abnormality were recorded. The abnormalities were furthered qualified as nodular, linear, airspace and mixed opacities.(Fig.2)

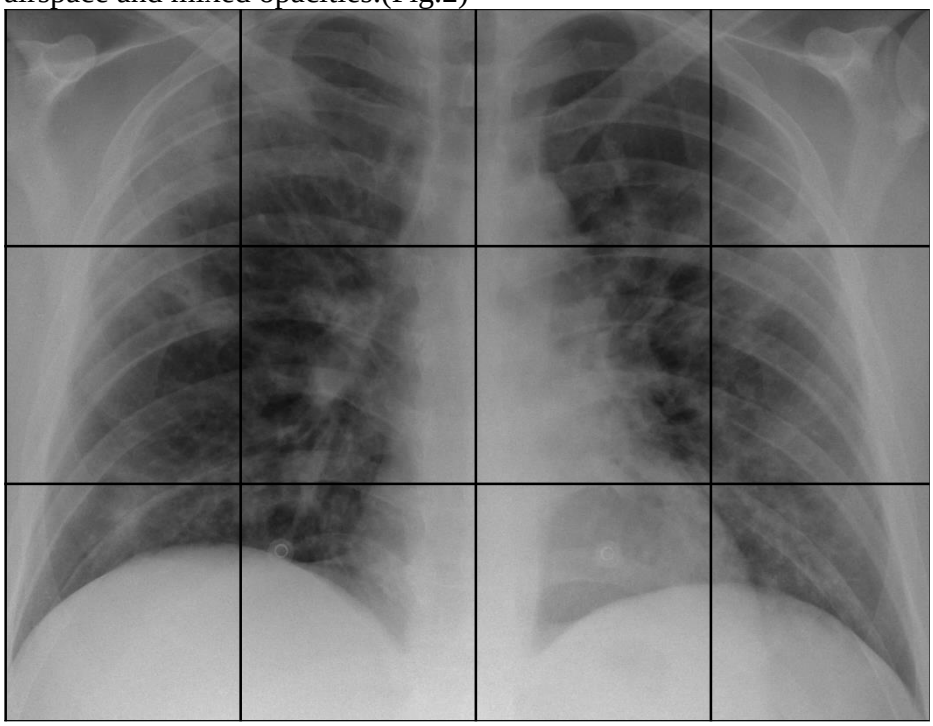
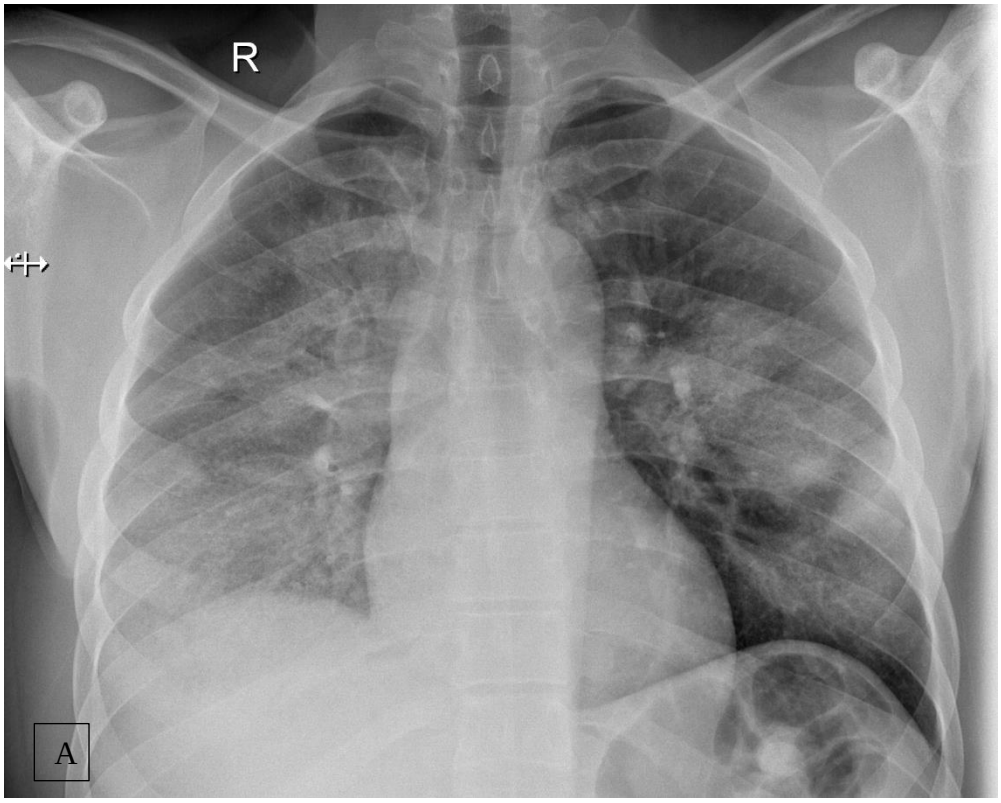


Figure 1: Chest radiograph were divided into 12 areas/zones for the assessment of the degree of involvement. 3 horizontal zones, upper, middle and lower divided by 2 vertical zones; central and peripheral zones.



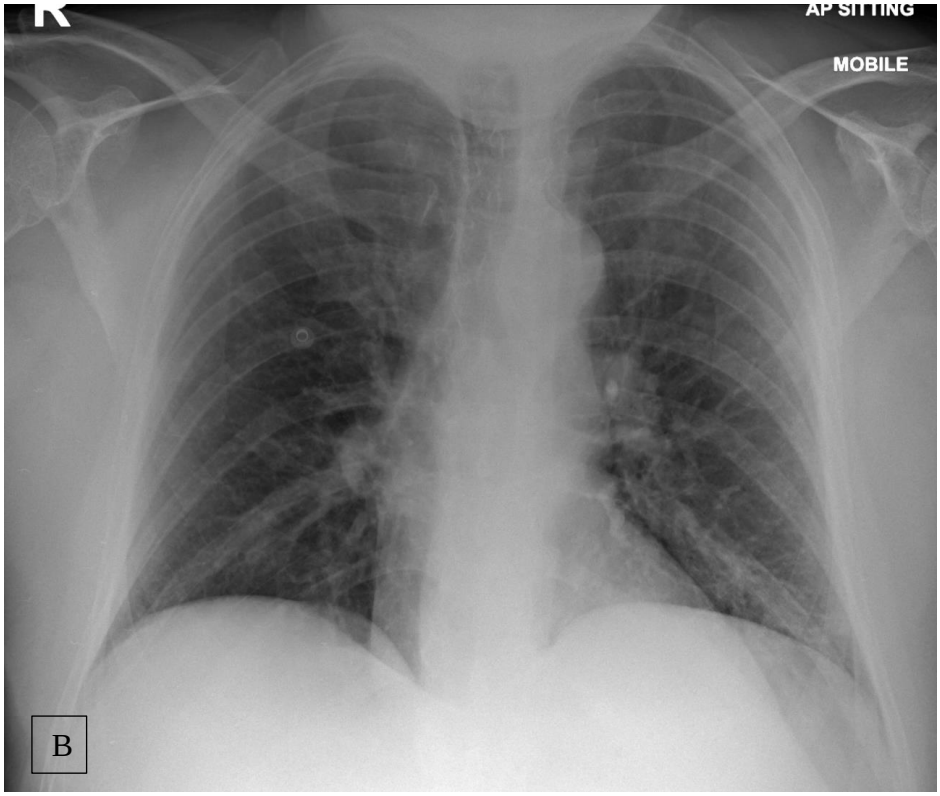


Figure 2: Chest Radiograph of Hospitalized Covid-19 Patients. A. Young man with positive Covid-19, chest radiograph showing air space pattern of opacities in middle and lower zones with prominent peripheral zonal involvement. B. Peripheral Left lower zone linear pattern of opacities. C. Multiple diffuse nodular pattern of opacities in Covid-19 patient who was eventually admitted to ICU.

The 2 radiologists reviewed the images independently, after this, any disagreement was resolved by discussion and consensus.

Data collection:

All data collection was obtained from the HIS and RIS. Patients demographics such as age, sex and citizenship were collected. The recorded comorbidities include hypertension, diabetes mellites, kidney disease and cardiovascular diseases. Immune status and smoking history were also collected. The radiological interpretation of the 12 areas were done by the radiologist for each case. The following laboratory tests, done at the time of admission, were collected; the white cell count (WBC), the lymphocyte count, the neutrophil cell count, the neutrophil/lymphocyte ratio (NLR), the C-reactive protein(CRP) level and the platelets count. Based on our institution laboratory normal values, the following was adopted as the ranges for values; CRP (Reference range : < 10 mg/L, Analytical sensitivity: 4 mg/L), WBC (2.4 - 9.5 10^9/L), Neutrophils count (1 - 4.8 10^9/L), Lymphocyte count (1.2 - 3.8 10^9/L) and Platelets (150 - 450 10^9/L).

COVID-19 confirmation test was done by RT-PCR test which is the molecular test used for disease definite diagnosis and confirmation. The tests were done in the national virology reference laboratory using more than one kit (liferiver, sunsure, Cobas SARS-CoV2; Roche). Validation and verification of used tests were done before use. All testing runs were done with controls.

The number of days from the onset of symptoms to hospitalization was obtained. Also, the length of stay in hospital was recorded. The outcome for the patients was obtained and recorded for 3 status, discharge, death or continued admission. At the time of writing this article few patients were still admitted with the outcome to be determined.

Data Analysis:

Statistical analysis was done using SPSS, version 20.0. Frequencies with percentages were reported for categorical data and medians with interquartile ranges were calculated for contentious data. Chi-square test considered for comparison between categorical variables and Mann-Whitney U test used to compare 2-independent samples. The difference was considered significant at $p< 0.05$ with a two-tailed test.

Results:

Demographic and Risk characteristics of cases

A Total of 26 Positive COVID-19 cases were enrolled in this study in which 11/26 (42%) have been intubated and 15/26 (58%) have not been intubated. (Table.1) The median age was 47.5 years [interquartile range (IQR) of 28 and 76 years] with no statistically significant difference between intubated and non-intubated cases (p=0.069). All the intubated cases were male (100%) and 10/11 were non-citizen (91%). The majority of intubated cases have at least one of the listed comorbidities in 9/11 (81.8%) as compared to 6/15 (40%) in the non-intubated group (p=0.051). There was a statistically significant difference in having diabetes

mellitus (p=0.020) in which 8/11 and 4/15 were recorded to have diabetes mellitus in intubated and non-intubated groups respectively.

Table1: Clinical and Laboratory Characteristics of Patients								
Variable		All N 26	%	Intubated cases N 11 (42.3%)		Non-intubated cases N 15 (57.7%)		p-value
Age	Median (25 and 75 IQR)	47.5 (34.8,67)	Max 76-min 28					0.065
Gender	Male	23	88.5	11	100	12	80	0.238
	Female	3	11.5	0	0	3	20	
Citizenship	Citizen	8	30.8	1	9.1	7	46.7	0.084
	Non-Citizen	18	69.2	10	90.9	8	53.3	
#Nasopharyngeal swabs till diagnosis	First	24	92.3	11	100	13	86.7	0.492
	Second	2	7.7	0	0	2	13.3	
Smoking History*	Yes	2	7.7	1	9.1	1	6.7	0.709
Comorbidities	Any comorbidity	15	57.7	9	81.8	6	40	0.051
	HTN[1]	9	34.6	5	45.5	4	26.7	0.419
	DM[2]	12	46.2	8	72.7	4	26.7	0.02
	Kidney D	2	7.7	0	0	2	13.3	0.492
	Cardiac D	3	11.5	1	9.1	2	13.3	1
	Immune deficient	1	3.8	0	0	1	6.7	1
Presenting symptoms	Respiratory symptoms	22	84.6	9	81.8	13	86.7	1
	Fever	20	76.9	8	72.7	12	80	1
	Cough	13	50.0	6	54.5	7	46.7	0.691
	SOB[3]	13	50.0	4	36.4	9	60	0.234
	Coryzal symptoms	7	26.9	3	27.3	4	26.7	1

	Headache	2	7.7	0	0	2	13.3	0.492
	Body aches	4	15.4	0	0	4	26.7	0.113
	Fatigue	11	42.3	3	27.3	8	53.3	0.246
	Diarrhea	4	15.4	2	18.2	2	13.2	1
	Chest pain	3	11.5	1	9.1	2	13.2	1
Days from symptoms to admission	Median (25 and 75 IQR)	7 days	(5,10) days					0.833
Parameters at admission	RR >30	16	61.5	8	72.7	8	53.3	0.428
	Elevated WBC (>10)	5	19.2	3	27.3	2	13.3	0.620
	Lymphopenia	22	84.6	11	100	11	73.3	0.068
	Elevated Neutrophil count (>6)	12	46.2	6	54.5	6	40	0.462
	Elevated CRP**:							0.099
	Mild	0	0	0	0	0	0	
	Moderate	11	42.3	2	20	9	60	
	Sever	14	53.8	8	80	6	40	
	Elevated NLR[4]	18	69.2	10	90.9	8	53.3	0.044
	Platelet:							0.8
	low	1	3.8	0	0	1	6.7	
	Elevated	1	3.8	1	9.1	0	0	
Outcome	Discharged	13	50.0	3	27.3	10	66.7	0.88
	Died	8	30.8	5	45.5	3	20.0	
	In hospital	5	19.2	3	27.3	2	13.3	

Note:* 2 cases missing (intubated cases), ** 1 case is missing
(1.Hypertension, 2. Diabetes Mellites, 3. Shortness of breath, 4. Neutrophil to Lymphocyte ratio)

Illness onset and clinical features of patients

The median number of days from developing symptoms to admission was f 7days [IQR; 5 and 10] ranging between 1 and 10 days with no significant difference between intubated and

non-intubated cases (p=0.8). (Table.1) The majority of cases presented with respiratory symptoms 9/11 (81.8%) and 13/15 (86.6%) and fever in 8/11 (72.7%) and 12/15 (80%) in intubated and non-intubated cases with no statistically significant difference between the two groups. 24/26 of the patients has a positive RT-PCR test for COVID-19 from the first swab.

Neutrophil to lymphocyte ratio (NLR) were elevated in 10/11 (90.9%) in intubated group compared to 8/15 (53.3 %) in non-intubated group (p=0.044). The median value of NLR was 6.11 (IQR; 2.98 and 9.69). (Table.1)

The intubated cases showed more elevation in CRP level at the time of hospitalization, with 2/11 (18%) were showing moderate elevation and 6/11 (54.5%) with sever elevation, compared to non-intubated cases with 9/15 (60%) moderate and 6/15 (40%) severe elevation. However, the differences were not statically significant (p=0.09).

Chest Radiograph findings

There were no differences found between the intubated and non-intubated CXR findings in terms of laterality involvement, the involvement of central and peripheral zones and type of lesions. (Table.2) However, upper zones involvement was more noted in the intubated group with 10/11 (90.9%) compared to 7/15 (46.6%) in non-intubated cases with p=0.036. In addition, there were higher numbers of zones involvement in intubated cases compared to non-intubated cases indicative of higher severity. Nine out of eleven (81.8%) of intubated patients had 10-12 zones of involvements on chest radiographs as compared to 3/15 (20%) in the non-intubated group. (Table.3)

TABLE2: CHEST RADIORAPHS FINDINGS OF THE 2 GROUPS

INVOLVEMENT	Intubated		Not intubated		All		p-value
	No.	%	No.	%	No.	%	
LATERALITY							
R LUNG	11	100	14	93.3	25	96.2	1
L LUNG	11	100	14	93.3	25	96.2	1
CENTRAL TO PERIPHERAL DISTRIBUTION							
CENTRAL ZONES	11	100	14	93.3	25	96.2	1
PERIPHERAL ZONES	11	100	14	93.3	25	96.2	1
CEPHALOCAUDAL DISTRIBUTION							
UPPER ZONES	10	90.9	7	46.7	17	65.4	0.036
MIDDLE ZONES	11	100	12	80	23	88.5	0.238
LOWER ZONES	11	100	15	100	26	100	1
TYPE OF LESION							
LINEAR	0	0	4	26.7	4	15.4	0.113
NODULAR	2	18.2	1	6.7	3	11.5	0.556
AIR SPACE	7	63.6	6	40	13	50	0.234

MIXED LESIONS	2	18.2	4	26.7	6	23.1	1

TABLE3: CHEST RADIOGRAPHS FINDINGS FOR THE 12 ZONES IN THE 2 GROUPS

INVOLVEMENT	Intubated		Not intubated		All		p-value
	No.	%	No.	%	No.	%	
ZONE INVOLVEMENT							
PRUZ	11	100	7	46.7	18	69.2	0.007
PRMZ	11	100	9	60	20	76.9	0.024
PRLZ	11	100	12	80	23	88.5	0.238
PLUZ	7	63.6	3	20	10	38.5	0.043
PLMZ	11	100	9	60	20	76.9	0.024
PLLZ	11	100	13	86.7	24	92.3	0.492
CRUZ	9	81.8	5	33.3	14	53.8	0.014
CRMZ	11	100	9	60	20	76.9	0.024
CRLZ	11	100	13	86.7	24	92.3	0.492
CLUZ	8	72.7	3	20	11	42.3	0.015
CLMZ	9	81.8	8	53.3	17	65.4	0.217
CLLZ	11	100	11	73.3	22	84.6	0.113
NUMBER OF ZONES INVOLVED							
1-3	0	0	4	26.7	4	15.4	
4-6	0	0	3	20.0	3	11.5	
7-9	2	18.2	5	33.3	7	26.9	
10-12	9	81.8	3	20.0	12	46.2	

Outcome:

Up to the day of data analysis, 8/26 patients died, 5/11 from the intubated group and 3/15 from the non-intubated group. Total of 13/26 were discharged home with 3/11 from the intubated group and 10/15 from the non-intubated group. Five patients included in the study were still admitted to the hospital by the time of writing this study. (Table1)

Discussion:

Covid-19 infection outbreak had been announced as a pandemic by the WHO on March 11, 2020.[2] With the increasing number of affected cases, the number of admission rises as well. This also implies a rise in admission to ICU and the need for mechanical ventilation. Approximately 20% of affected cases require hospitalization and 5% require admission to ICU and mechanical ventilation.[18] Imaging using chest radiograph and computed tomography are recommended modalities at the triage room, based on availability. In this research, we studied the available chest radiographs of all admitted patients with confirmed COVID-19 infection. We compared the radiographical and clinical findings between the group of patients who were admitted to the ICU and intubated to the group of patients who remained hospitalized but without the need for intubation and ICU admission.

In our study, the male gender represents the majority of all hospitalized cases with 88.5%, and 100% among the intubated cases. Approximately one-third of the cases were citizens and two-thirds are non-citizens.

The majority of patients presented with fever, cough and shortness of breath. The results are similar to what was previously published from other different parts of the world including Oman.[4, 5, 13, 19-21] Headache was the least presenting symptom representing 7.7%.

The radiographic findings in our group re-demonstrate the lower and basal preference of disease distribution. [17, 22-26] There were more areas of involvement representing worse radiographic severity in the intubated group. 81.8% of intubated patients have 10-12 areas of involvement in their chest radiographs compared to only 20% of the hospitalized non intubated group.

The distribution showed that there is more peripheral involvement then central among the intubated cases. The right lung peripheral areas, in the 3 horizontal zones, were 100% involved among the intubated group. The peripheral left upper zone (P-LUZ) was the least area of involvement among both groups.

Our study has several limitations. First limitation is the smaller sample size that could affect the statistical significance measures. Further studies with larger sample size are needed in future. The second limitation is that it's a retrospective study, therefore there could be a possible effect on the measured outcome. The third limitation is that not all information, particularly about some of the patients' outcome, were available at the time of conduction of the study. Some of the included patients were still admitted at the time of publication. The fourth limitation is that most of the information were gathered from the electronic hospital information system which precluded the level and diversity of details collected.

Conclusion:

The initial radiographic findings among intubated and non-intubated hospitalized COVID-19 patients demonstrate differences in the degree of lung involvement represented in the number of areas involved. Also, more upper zone involvement was noted in the intubated group at the time of admission. The other radiological findings showed no significant differences. Male sex and diabetes mellites carry a poorer prognosis and were more associated with the intubated group. The sample size of this study was small, therefore further studies with larger sample sizes are needed in future to support these initial findings.

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