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Original Article

Chest X-ray (First Tool of Imaging) in COVID-19 Patients Radiological and Clinical Correlation - A Tertiary Care Experience at Jinnah Postgraduate Medical Centre, Karachi

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Abstract

Background: COVID-19 infection is the name given to respiratory illness caused by novel coronavirus (nCov) which is a new strain emerged in China in December 2019 that has not been previously identified in humans. Coronaviruses are a large family of viruses that cause illness ranging from common cold to severe respiratory symptoms of pneumonia. As there is no fixed definition of COVID-19 pneumonia, in this article we use tis term for patients who clinically showed up with respiratory symptoms along with radiological evidence of disease.
Objective: The objective was to correlate the chest x-ray findings of all symptomatic COVID-19 PCR (polymerase chain reaction) positive patients admitted in COVID-19 isolation ward, Jinnah Postgraduate Medical Centre (JPMC), Karachi and assess the extent of baseline illness with progression or regression of disease radio graphically through serial chest X-rays and clinically with repeated viral nucleic acid testing.
Study type, settings & duration: A prospective observational study was conducted at JPMC from 1st May to 31st May 2020.
Methodology: All RT-PCR COVID-19 positive patients included who were admitted at isolation ward. Baseline and serial chest x-rays of suspected and already diagnosed patients were performed using portable x-ray machine dedicated in COVID-19 isolation ward.
Results: Sixty four patients were studied over a period of one month, 42 males (66%) and 22 females (35%) in the age range of 16-75 years were included. The 23% patients with mild symptoms had normal chest radiograph initially progressed gradually with classical radiographic features had severity score (2) to moderate to severe involvement of lungs on an average 8-10 days after symptom onset with severity score =>3. The 7% patients with moderate symptoms showed moderate baseline chest x-ray COVID-19 features of severity score=>3 at the time of admission. The 44% patients with severe symptoms showed diagnostic baseline chest x-ray features with severity score =>4.
Conclusion: Symptomatic COVID-19 positive patients showed chest x-ray features of mild to moderate ground glass opacities in sub pleural and peripheral distribution whereas in severe cases superimposed consolidation was also frequently noticed.
Key words: Chest x-rays (CXR), RT-PCR (Real time polymerase chain reaction), consolidation, interstitial features, multifocal.

Introduction

Everyday emerging pathogens poses worldwide challenges to the human health. Corona virus infected a cluster of patients in December 2019 in Wuhan City, Hubei province of China with respiratory symptoms linked to the seafood wholesale market labeled as 'pneumonia of unknown etiology'.[1] The pulmonary syndrome caused by novel strain of beta coronavirus isolated from the lavage taken from upper respiratory tract or from a nasopharyngeal swab. It was given an acronym of COVID-19 and declared a Public Health

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Authors Contribution

MAM conceptualized the project. SK did the literature search. Evaluation of chest x-rays was performed by NA. TM did the supervision. Data collection and drafting, revision & writing of manuscript were done by UK.

Emergency of International concern (PHEIC) by WHO in a meeting on January 30, 2020 as it had already spread to 18 countries by that time.[2,3] International Committee on Taxonomy of Viruses (ICTV) termed it as SARS-CoV-2 virus. It caused illness very much similar to the one that caused SARS outbreak 20 years ago earlier in the century.[2] Later on, WHO declared it a global pandemic on 11th March, 2020. This new virus seemed to be very contagious and lethal, affected more than 7 million people globally and approximately,[1] 44,000+ confirmed cases in Pakistan uptil 14th June, 2020.[4] A comprehensive study of mammalian host-virus relationship demonstrated that bats harbor a significantly higher proportion of zoonotic viruses than other mammalian orders.[5] Viruses from most of the viral families can be found in bats[6] Enveloped single-stranded RNA corona viruses are widely pathogenic among humans and other mammals causing predominantly respiratory and less likely enteric, hepatic and neurologic illnesses.[7] Few of its strains causes typical flu and common cold like symptoms while two of its lethal strains SARS-CoV (severe acute respiratory syndrome coronavirus) and MERS-CoV (Middle East respiratory syndrome coronavirus) were responsible for severe respiratory distress syndrome outbreaks in 2002 in China and in 2012 in Middle Eastern countries respectively. A wide range of symptoms are related to COVID-19 infection, from mild upper respiratory complains to profound respiratory distress, though a proportion remains asymptomatic too.[8,9] Our research aimed to study and correlate radiographic features in chest x-rays upon admission and during the course of illness at hospital stay in COVID-19 positive patients with their clinical symptoms and RT-PCR status. Regarding imaging, CT scan chest is unquestionably superior in earlier and accurate diagnosis for lung lesions but disinfection of equipment and spread of cross-infection to other patients as well as radiology department staff via CT suite was a major concern. American College of Radiology (ACR) and local governmental guidelines advocate use of portable chest x-rays for differentiation of COVID-19 pneumonia from other causes of pulmonary pathologies.[10] In countries like Pakistan, especially public sector hospitals, where limited resources to work with, clinicians had to rely on portable chest x-rays.

Methodology

A prospective observational study of 64 patients carried out at a tertiary care hospital, Jinnah Postgraduate Medical Centre Karachi, from 1st May to 31st May. Only RT-PCR positive patients admitted in COVID-19 isolation ward were included. Study focused on initial CXR findings in RT-PCR COVID-19 positive patients at the time of admission and their correlation with severity of clinical symptoms, onset of disease, through the course of illness during hospital stay and as well as their clinical, radiologic and virologic recovery at the time of discharge, hence serial chest x-rays were taken. All portable chest x-rays were taken by digital radiographic technique at fixed 100-110 KVP of any same patient with little variation done in KVP settings depending upon patient's habitus. Majority x-rays were antero-posterior (AP) projections with patient either sitting or lying in supine position. Serial radiographs were read by three senior radiologists were classified according to the scoring system developed by radiologists for COVID-19 radiographs worked at the Mount Sinai Hospital, New York. According to this system they divided each patient's chest x-ray into six zones; upper, mid and lower zone each lung and awarded one point to each zone based upon the presence of opacity in that zone while zero assigned to the zones with no opacities. A severity score of >2 is independent predictor of hospital admission while severity score of >3 is independent predictor of chest intubation.[11]

The Ethical approval was obtained from Institutional Review Board of Jinnah Postgraduate Medical Centre, Karachi.

Results

There were 42 (66%) males and 22 (33%) female patients. Age range of patients varies from 16-75 years, with mean age of 52 years. All were real time reverse transcription polymerase chain reaction (RT-PCR) positive.

Of clinical symptoms, fever (84%), dry cough (89%) and myalgia (69%) remains on the top of the list while shortness of breath (44%) with varying percentage of oxygen saturation was one compelling feature which raises the need of hospitalization. Few uncommon symptoms reported were anosmia, anorexia and loss of taste sensations as well. Of all 41% patients had a history of travel/contact. Most patients recovered well. Severe and critical illness with adverse outcome occurs in greater percentage in elderly and with co-morbidities. Co-morbidities in our setup were mostly hypertension, diabetes mellitus, ischemic heart and chronic liver diseases (Table-1).

Total of 23% patients with mild symptoms of low grade fever and sore throat had normal chest radiograph. The patients who initially had mild clinical symptoms of fever and sore throat

Table 1: Patient's clinical data.

S.No			*Findings*
1	Age	Mean	52 years
		Range	16-75 years
2	Gender	Male	42 (64%)
		Female	22 (34%)
3	H/O Travel/ Contact		27 (41%)
4	Symptoms	Sore throat	20 (30%)
		Cough	58 (89%)
		Fever	56 (85%-90%)
		Shortness of breath(at the time of admission)	29(44%)
		Shortness of breath(after 5-6 days of hospital admission)	13 (20%)
5	Clinical Signs	% O2 Saturation (<92%)	10 (15%)
		% O2 Saturation (<72%)	29 (44%)
6	Co-morbidities	Hypertension	20 (30%)
		Diabetes Mellitus	15 (25%)
		Smoker	04 (6%)
		CLD	35 (53%)
		IHD	08 (12%)

Table 2: Radiographic findings.

Radiologic Properties	*Categories*	***N (%)***
Severity	Normal	15 (23)
	Mild	15 (23)
	Moderate	5 (7)
	Severe	29 (44)
Types of Infiltrate	Interstitial	10 (15)
	Ground glass opacities (GGO)	12 (18)
	Consolidation	39 (60)
Zones	Lower	28 (43)
	Mid + Lower	26 (40)
	Diffuse	10 (15)
Location	Multifocal	15 (23)
	Focal	39 (61)
	Bilateral	43 (66)
	Peripheral	34 (51)
	Central	6 (9)
Other	Effusions	2 (3)
	Lymphadenopathy	Nil

progressed gradually with complaint of breathlessness and classical radiographic progression of disease from mild baseline bilateral lower zone sub pleural interstitial shadowing (severity score=2) from moderate to severe involvement of either unilateral or bilateral middle zones showing multifocal consolidative patches along with ground glass haze on an average 8-10 days after symptom onset (severity score >3) as shown in Figure-1. The 7% patients presented with fever, myalgia, shortness of breath and their chest X ray showed moderate baseline chest x-ray COVID-19 features(severity score=>3) (Table-2). Among all 44% patients who presented with

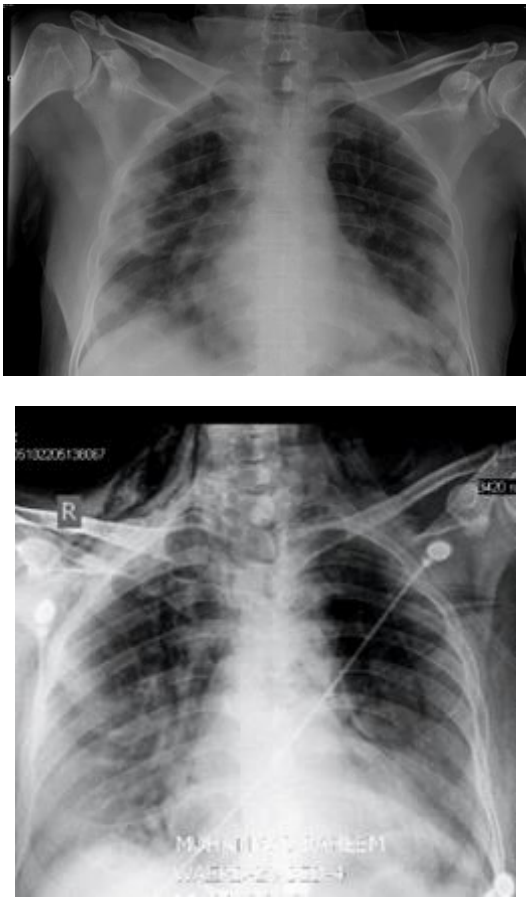

Figure 1: Chest radiographs of a patient on day 2 and 8 of admission showing gradual progression of radiographic features from bilateral peripheral multifocal patches of consolidation (right > left) to combination of ground-glass haze with consolidation completely in involving both lower and right mid-zones.

shortness of breath and varying oxygen saturation between 70-92% showed diagnostic baseline chest x-ray features of multifocal irregular opacities or alveolar consolidations superimposed on ground-glass haze progressing larger within days diffusely involving bilateral lower and mid zones or even a unilateral hemi-thorax giving a white-washed appearance and this was a more specific predictor of a rapid progression of disease (severity score >4)as shown in Figure-2.

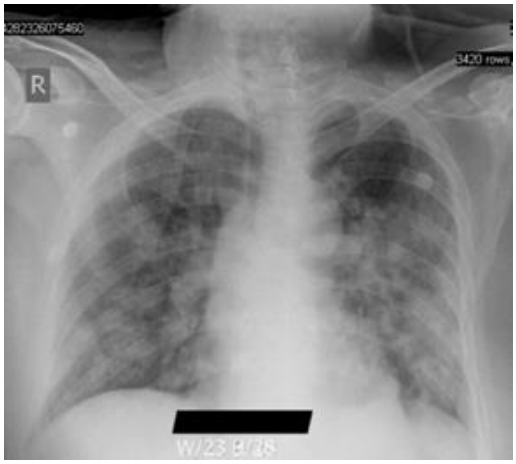

Figure-2; Chest radiograph of a 75 year old RT-PCR positive patient on day 9 of illness showing bilateral multifocal patches of consolidation superimposed on ground glass haze more marked in lower lung fields. There is no evidence of pleural effusion in either costophrenic angle.

Good percentage of patients (84%) recovered though and showed regression of radiologic features as well as improvement of clinical symptoms. Virologic recovery was also confirmed by negative PCR status before discharge. It was one major observation that some patients however didn't show complete resolution of radiologic signs on chest x-rays before discharge, reticular shadows and septal thickening persists in 9/64 (14%) patients which were advised a close follow-up.

Discussion

Since the COVID-19 infection has begun in China producing predominantly respiratory symptoms, so the need of radiologic evaluation of chest became crucial. Initial reports from Wuhan, China elaborated human-to-human spread of SARS-CoV-2. Transmission of SARS-CoV-2 from asymptomatic individuals has also been reported.[12,13] People were generally susceptible, need of social distancing and use of face masks were emphasized in order to stop the spread of infection but by that time unfortunately it had already spread to other parts of the world despite strict travel bans. Incubation period of the disease is usually 1-14 days, least be 3-7 days.[14]

The role of imaging specially CT in detecting early lung changes alongside real time RT-PCR were found specific but as the time goes by and cases started multiplying, hospitals in China dedicated a few CT scanners in fever clinics for COVID-19 suspected patients from January 2020 according to data available on imaging studies of COVID-19 patients from different hospitals in China.[15,16] Unfortunately, the disease spreads from China to other parts of the world in no time including USA, UK and Asia Pacific regions, it was decided unanimously by the team of radiologists, pulmonologists, experts in emergency medicine and infection control, with members from three continents of the world that need of CT scan must be limited only to critically ill indeterminate cases while liberal use of chest x-rays in any patient with moderate to severe clinical features was advised regardless of their COVID-19 test results.

Spectrum of features extending from only consolidation to pure ground glass haze or mixed ground glass opacities with consolidation predominantly in bilateral, peripheral lower zones ascending peripherally or more specifically sub-pleurally as it can very well be central under mediastinal pleural reflections as well helps in assessment of severity of disease. Radiographic correlation with clinical and important laboratory parameters certainly used as a definite prognostic indicator of COVID-19. Upon correlation with clinical features it was observed that radiologic findings often lag behind in mild to moderate cases in the beginning. As keeping in view a study conducted by Choi et al which concluded with, "Clinicians and radiologists should keep in mind that a greater extent of disease can exist than that suggested by inspection of radiographs, and that radiographs may also have limitations for monitoring the disease extent".[17] The consensus statement on the role of imaging in management of COVID-19 infected patients released by Fleischner Society for Thoracic Imaging and Diagnosis says, "Imaging is indicated in patients with COVID-19 and evidence of worsening respiratory status and when access to CT is limited, chest radiography be preferred for COVID-19 patients unless features of respiratory worsening warrant using CT".[18] Although chest x-rays are less sensitive than CT scans, the former however now used as a first radiologic approach because of its easy availability and ease of decontamination in almost every country suffering from COVID-19 all over the world.[19]

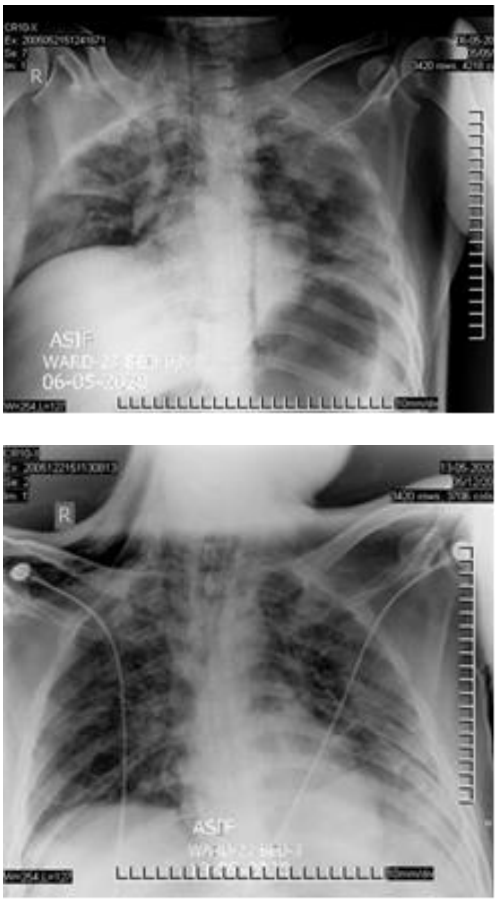

Figure-3: Chest Radiographs of the patient on days 8 and 15 after the onset of illness. Endotracheal tube was instituted and mechanical ventilation provided in the period between the acquisitions of two images. Bilateral multifocal patches of consolidation with air bronchogram and ground glass haze appearance seen in Image 1 showing improvement of lung expansion in post intubation Image 2.

In a cohort of patients admitted at isolation ward JPMC, 46% RT-PCR positive mild symptomatic patients admitted, half of them had normal baseline chest x-rays while rest had mild Covid-19 radiographic features. These 23% patients with minimal symptoms and almost no abnormal radiographic features were not kept in hospital and advised home isolation. Symptomatic patients with mild shortness of breath 8% patients having oxygen saturation less than 92% were admitted out of suspicion whom RT-PCR results awaited as baseline chest x-rays showed typical COVID-19 features. The 44% patients admitted with percentage of oxygen saturation between 70-92% or having tachypnea with respiratory rate of more than 25-30 breathes/min with co-morbidities showed moderate to severe lung involvement on baseline chest x-rays were showing hypoxemic status with increased CO_2 % in blood of >40% while nucleic acid testing with reverse transcription polymerase chain reaction (RT-PCR) was still not done by then, were strongly suspected and hence RT-PCR done within hours, were turned out positive later. These patients were intubated as shown in Figure-3 and gradual regression of radiographic COVID-19 features along with improved oxygen saturation was observed and visible lung expansion seen.

On the basis of chest x-rays, we can categorize disease process at its mild, moderate and severe level depending upon the extent of lung involvement. While reporting, severity score assigned to each lung depending upon its involvement according to scoring system made at Mount Sinai Hospital, New York. A severity score of />2 was given to the patients who had initial subtle radiographic features of either single zonal involvement or multiple nodules in one or two lung zones in 23% in our studied cases as compared to 10% patients in Mount Sinai Hospital, New York. A severity score of >3 was assigned to 44% patients showing opacification of more than two zones showing statistically significant difference with the study conducted at Mount Sinai Hospital, New York. The 63% patients had severity score of >3 due to opacities in more than two lung zones.[11] As score of more than three was an independent predictor of chest intubation for deterioration of respiratory symptoms, according to this scoring system statistically more patients were intubated in US population as compared to our population of patients admitted with COVID-19 illness. Those patients who were admitted with the severity score of >4 or 5 on baseline chest x-rays, suspected to had a bad prognosis and definite radiographic progression of disease was also noted during the course of illness from focal to confluent patches of bilateral lower zone ground glass opacities with superimposed consolidation usually sub-pleural in location ascending peripherally and in perihilar regions leading to architectural distortion.[20] However in a number of intubated patients a clear observation of regression of radiographic features and better lung expansion owing to improvement in oxygen saturation was also seen as shown in Figure-2. Overall, the imaging changes found at its peak on days 8-10 of illness as were reported in literatures related to hospitalize COVID-19 patients from other parts of the world.

It is of special concern that radiologic appearance of consolidation with air-bronchogram and other interstitial findings are actually non-specific signs which indicate acute lung injury as seen in any other organizing /atypical pneumonia of other etiologies, hence possibility of superadded bacterial infection or aspiration pneumonia must be

considered while labeling indeterminate lung features on chest x-rays.[20] The actual distinguishing feature was the distribution pattern; which in our study was predominantly peripheral (52%), however could be central or perihilar under mediastinal pleural reflections. The 8% or both 23%, usually asymmetrical multifocal nodular involvement in bilateral lower zones 51/65 (78%)was one consistent finding studied in patients under observation.[21] On correlation of radiographic with virologic and clinical recovery, clinical improvement occurred side by side of virologic recovery in (80%) of patients however radiologic recovery in 75% patients, which lag behind virologic recovery. The 23% mild symptomatic positive patients did not have baseline chest x-ray findings, however 44% severely symptomatic suspected patients which later turned out RT-PCR positive had definite baseline CXR findings.[22] Hence sensitivity of initial RT-PCR (90%) was higher than baseline CXR (67%) in our study. RT-PCR which is still taken as gold standard showed specificity in (90%) patients on very first sampling taken from upper respiratory tract, however chest x-rays showed up specificity in 67% of our population group as were also reported similar to many other studies in different parts of the world.

Additionally, Sheng et al [23] in a study found that viral infections can increase the risk of pulmonary fibrosis.[24] Therefore, prevention of pulmonary fibrosis may be one of the severe issues in COVID-19 recovered patients that need to be addressed.

Study concluded with the fact that portable chest x-rays were found out to be the most effective and readily available imaging modality which provided an early insight into chest findings of COVID-19 patients. Its easy availability in specific COVID-19 treatment unit and minimal chances of spread of infection in between patients as relatively rapid cleaning and decontamination of portable CXR equipment makes it superior to CT scanners as baseline imaging modality, however negative CXR does not completely exclude the diagnosis of COVID-19 though.

As the imaging section of our study was only focused on a single modality of portable chest x-rays, this limits the further confirmation of radiologic findings via CT chest especially in the early and recovery phase of disease. As in the early phase of disease negative CXR does not exclude the diagnosis of COVID-19, CT chest was the need of time. Secondly, a few number of patients had come up with atypical chest findings irrelevant to COVID-19 at some point during the course of illness could be due to some other viral/ bacterial pathology and were needed to rule out by chest CT which due to the reason of spread of infection patients were not sent for it. Lastly, patients who were followed to their virologic, clinical and radiologic recovery, few of them did not have complete resolution of radiological features at the time of discharge but were not able to be followed up till complete radiologic recovery.

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Conflict of interest: None declared.

References

1. Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, et al. A novel coronavirus from patients with pneumonia in China, 2019. New England J Med 2020; 382(8): 727.
2. World Health O. Coronavirus disease (COVID-19) pandemic. (Accessed on 6th June 2021) Available from URL:https://www.who.int/emergencies/diseases/novel-coronavirus-2019
3. World Health O. Novel coronavirus. (Accessed on 6th June 2021) Available from URL:https://www.who.int/dg/speeches/detail/WHO-Director Generals statement on ihr emergency committee on Novel coronavirus-(2019-Ncov)
4. Worldometer's COVID-19 data. (Accessed on 6th June 2021) Available from URL:https://www.worldometers.info/coronavirus/country/pakistan/
5. Fan Y, Zhao K, Li Shi Z, Zhou P. Bat Coronavirus in China. Viruses. 2019; 11(3): 210.
6. Wang LF, Cowled C. Bats and Viruses: A New Frontier of Emerging Infectious Diseases; John Wiley Sons Inc: Hoboken, NJ, USA, 2015.
7. Olival KJ, Hosseini PR, Zambrana-Torrelio C, Ross N, Bogich TL, Daszak P. Host and viral traits predict zoonotic spillover from mammals. Nature 2017; 546: 646-50.
8. Wu Z, Yang L, Ren X, He G, Zhang J, Yang J, et al. Deciphering the bat virome catalog to better understand the ecological diversity of bat viruses and the bat origin of emerging infectious diseases. ISME J 2016; 10: 609-20.
9. Zhou P, Yang XL, Wang XG, Hu B, Zhang L, Zhang W, et al. A pneumonia outbreak associated

with a new coronavirus of probable bat origin. Nature2020; 579(7798): 270-3.
10. ACR Recommendations for the use of Chest Radiography and Computed Tomography (CT) for Suspected COVID-19 Infection | American College of Radiology. (Accessed on 6th June 2021) Available from URL:https://www.acr.org/Advocacy-and-Economics/ACR-Position- Statements/Recommendations-for-Chest-Radiography-and-CT-for-Suspected-COVID19-Infection
11. Toussie D, Voutsinas N, Finkelstein M, Cedillo MA, Manna S, Maron SZ. Clinical and Chest Radiography Features Determine Patient Outcomes In Young and Middle Age Adults with COVID-19. , Radiology 2020; 297(1): E197-206.DOI: 10.1148/radiol.2020201754
12. CDC COVID-19 Response Team. Severe outcomes among patients with coronavirus disease 2019 (COVID-19) - United States, February 12 -March 16, 2020. MMWR Morb Mortal Wkly Rep 2020; 69: 343-6.
13. Coronavirus disease 2019, Situation Summary; Centers for Disease Control and Prevention (CDC). (3/18/2020). (Accessed on 6th June 2021) Available from URL:https://stacks.cdc.gov/view/cdc/85956
14. Linton NM, Kobayashi T, Yang Y, Hayashi K, Akhmetzhanov AR, Jung S. et al. Incubation period and other epidemiological characteristics of 2019 novel coronavirus infections with right truncation: a statistical analysis of publicly available case data. J Clin Med 2020; 9(2); 1-9
15. Yang W, Cao Q, Qin L, Wang X, Cheng Z, Pan A, et al. Clinical characteristics and imaging manifestations of the 2019 novel coronavirus disease (COVID-19): A multi-center study in Wenzhou city, Zhejiang, China. J Infect 2020; 80(4): 388-93.
16. Qu J, Yang W, Yang Y, Qin L, Yan F. Infection Control for CT Equipment and Radiographers' Personal Protection During the Coronavirus Disease (COVID-19) Outbreak in China. AJR Am J Roentgenol 2020; 215(4): 940-4
17. Choi H, Qi X, Yoon SH, Park SJ, Lee KH, Kim JY, et al. Extension of coronavirus disease 2019 (COVID-19) on chest CT and implications for chest radiograph interpretation. Radiology. 2020; 2(2): e204001.
18. Rubin GD, Ryerson CJ, Haramati LB, Sverzellati N, Kanne JP, Raoof S, et al. The role of chest imaging in patient management during the COVID-19 pandemic: a multinational consensus statement from the Fleischner Society. Chest 2020158(1): 106-16.
19. Wong HYF, Lam HYS, Fong AH, Leung ST, Chin TWY, Lo CSY, et al. Frequency and distribution of chest radiographic findings in COVID 19 positive patients. Radiology 2020; 296(2): E72-8.
20. Ng MY, Lee EYP, Yang J, Yang FF, Li X, Wang H, et al. Imaging profile of the COVID-19 infection: radiologic findings and literature review. Radiology: Cardiothoracic Imaging 2020; 2(1): 1-9
21. 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; 214(6): 1287-94..
22. Antonio GE, Ooi CG, Wong KT, Tsui ELH, Wong JSW, Sy ANL, et al. Radiographic-clinical correlation in severe acute respiratory syndrome: study of 1373 patients in Hong Kong. Radiology 2005; 237(3):1081-90.
23. Sheng G, Chen P, Wei Y, et al. Viral infection increases the risk of idiopathic pulmonary fibrosis: a meta-analysis. Chest 2020; 157(5): 1175-87.
24. Sun P, Lu X, Xu C, Sun W, Pan B. Understanding of COVID-19 based on current evidence. J Med Virol 2020; 92(6):548-51.