CXR SEVERITY SCORES OF COVID 19 INFECTION IN SRI LANKA: FINDINGS OF A MULTICENTER STUDY DURING THE FIRST WAVE OF THE PANDEMIC

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Abstract

Introduction

Chest X-ray initially remained the only imaging modality in the first wave of the COVID -19 pandemic in Sri Lanka similar to many other low resource settings. Sri Lanka claimed a cluster epidemic status achieving a case fatality rate well below the global rate during the first wave.

Objectives

To describe degree of lung involvement on CXR as a severity score and correlate severity scores with symptom duration, presence of comorbidities and demographic factors.

Methods

A retrospective study at four main hospitals in Sri Lanka included all RT-PCR positive COVID-19 patients who underwent CXR from January to mid May, 2020. Both initial and follow-up CXR were independently double reported by a team of four radiologists and discrepancy reported by a fifth radiologist for radiographic findings and lung involvement. Clinical and demographic data was retrieved from hospital records. A severity score was calculated for each CXR. Associations were analyzed for CXRs with a severity score of 1 or more.

Results

217 CXRs of 133 patients (99 men, mean age 43.9±15.7 years;133 initial CXRs of 132 symptomatic patients; 84 follow-up radiographs of 33 patients) revealed 96(96/133;72.2%) normal initial CXRs. 12 patients with normal initial CXRs(12/96;12.5%) underwent follow up CXR but none was abnormal. Majority (21/37;56.75%) with abnormal CXR had mild (severity score 1-2) lung involvement. A severity score of 1 or more was associated with comorbidities (OR=3.14), male sex (OR=5.93) and increasing age (OR=1.06).

Conclusion
Majority of CXR in COVID-19 patients were normal during first wave in Sri Lanka. Majority with abnormal CXR had mild lung involvement.

Introduction

2019 Novel corona virus disease (COVID -19) was recognized when a number of cases of "unknown viral pneumonia" started to be reported from Wuhan City, Hubei Province, China from 19 December 2019. On 30th January 2020 World health Organization declared COVID-19 as a Public Health Emergency of international Concern (PHEIC) and subsequently on 11 March 2020, COVID-19 was recognized as a pandemic(1). COVID-19 reached Sri Lanka on 27th January 2020, when the first confirmed case, found to be a Chinese national who came to Sri Lanka as a tourist, was reported in Colombo. The first Sri Lankan national with COVID-19 was detected on 11th March 2020 and since then new patients were identified and managed, with their contacts quarantined. During the first COVID -19 wave in the island, Sri Lanka was able to control the spread of the infection to a cluster epidemic status achieving a case fatality rate well below the global rate.

Many initial studies during this period revealed CXR to be abnormal in majority of symptomatic patients with some highlighting the lack of sensitivity of CXR(2) (3). Sri Lankan hospitals which were dedicated for managing patients with COVID-19 had to rely on CXR as the only imaging modality during the initial part of the first wave. Computed Tomography (CT) was not available at these centers and patients could not be routinely transferred or referred to centers with better imaging facilities for the obvious reasons of unit contamination and cross infection.

This multicenter study, conducted during the first wave of the pandemic in Sri Lanka, while the country was at a cluster epidemic setting, aimed to assess the degree of lung involvement on CXR in terms of a severity score and correlate the lung severity scores with the duration of symptoms, presence of comorbidities, age, sex and smoking status.

Material and Methods

This retrospective study was approved by the Ethics Review Committee, Faculty of Medicine, University of Colombo (Reference number: EC/20/EM04; approved on 13 May 2020). Study was conducted simultaneously in the four main hospitals that managed RT-PCR positive COVID-19 patients in Sri Lanka from the inception of the disease in the country in January 2020 to 15th May 2020 during the first wave of COVID-19 in the island. These hospitals were dedicated for managing patients with COVID-19.

During the study period, the total RT-PCR positive COVID-19 cases in the country were 925(4), and these four hospitals managed a total of 655(70.8%) out of the reported 925 RT-PCR positive COVID-19 patients in the country, arising mainly form 3-4 clusters, during the study period(5). Approval for the study was

taken from all four hospitals. Patient consent was waived.

Participants: All patients diagnosed as COVID-19 by RT-PCR testing, who underwent Chest x-ray after admission to the above hospitals were included in the study. Patients whose chest x-rays were not saved in retrievable format in radiology department databases of these hospitals were excluded. Figure 1 shows the flow chart for selection of participants.

Image and data acquisition: X-rays acquired according to local departmental protocols as portable inward radiography and developed by computed radiography(CR). Both AP (Anteroposterior) and PA (Posteroanterior) CXR were included; PA radiographs were acquired using a locally made apparatus (figure 1S in supplementary data) specifically made to cater for COVID patients during the latter part of the study period at the main hospital which managed these patients. The chest X- ray images were retrieved from the radiology department databases for reporting. All chest x-rays of these patients acquired during same admission were included (The first chest x-ray of each patient was named the 'initial x-ray' for the purpose of identification and analysis; any other chest x-rays of the same patient were called follow-up x-rays in chronological order of image acquisition). Clinical and demographic data were retrieved from bed head tickets and admission / discharge registers and radiology department registers.

Data quality scoring and analysis: CXR were initially independently double reported by a team of four radiologists with 6 to 12 years of post doctoral radiology experience. The team comprised of the single radiologists of each hospital (n=4). In the event of any discrepancy between the first two readers' decisions a fifth radiologist (radiologist in charge at the National Hospital for Respiratory Diseases, Sri Lanka with 12 years of post-doctoral radiology experience) made the final decision. The third reporting radiologist was not blinded to initial double reporting data. Diagnosis of consolidation, ground glass opacifications and nodules were based on Fleishners criteria(6). Radiographic findings were assessed for predominant distribution (peripheral, perihilar or neither) and lung zone involvement (upper, mid and lower; and for side (bilateral, right or left). The data was entered to Statistical Package for the Social Sciences software version 22.0 and is described using descriptive statistics. Radiographic findings were initially analysed for frequency and compared with the clinical data. A severity score was calculated for each lung similar to the methodology used by Wong et al (7): a score ranging from 0-4 was assigned to each lung depending on the degree of involvement by consolidation or ground glass opacity (0 = no involvement; 1 = <25%; 2 = 25-50%; 3 = 50-75%; 4 = >75% involvement). The scores for each lung were summed to produce the final severity score (Maximum score for a chest X-ray was 8). Severity scores of initial CXR, all CXR (both initial and follow-up x-rays) and the highest severity scores reached by each patient were analyzed separately. Thereafter the severity scores of initial chest x-rays was categorized into two. Those with a score of zero and those with a score of 1 or more. The characteristics of the patient were explored for an association with the categorized severity using Chi Square statistics and Mann-Whitney U test. Thereafter a logistic regression was carried out to observe the unconfounded effects on severity score category which was the dependent variable. Both categorical and continuous types of data were included as independent variables. All the independent variables were applicable to the total population of 133.

Results

One hundred and fifty (150/655; 22.9%) out of the 655 patients admitted to the four hospitals underwent chest radiography during the study period. One hundred thirty three (133/150; 88.7%) of these patients were included in the study; 17 (17/150; 11.3%) patients were excluded (Figure 1).

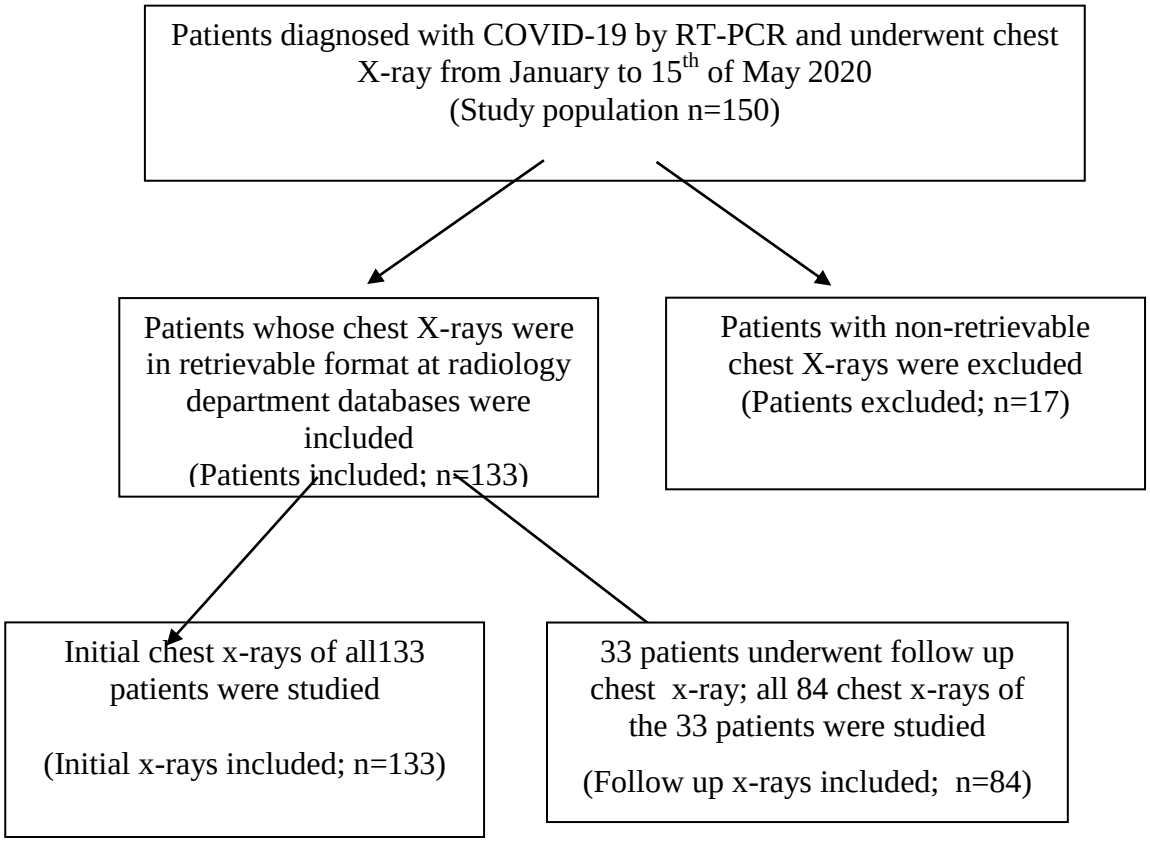

Figure 1 – Study Participants' Flow Chart (217 chest X-rays of 133 patients were included)

Demographic and morbidity pattern of the study participants (n= 133, Table 1)

Table 01: Characteristics of the study population (n=133)

Characteristic	**figures**
Age	
Mean age	43.9(SD=15.7) years
Age range	4-94 years
Inter-quartile range	21 years
Gender	
Male	99 (74.4%)

Female	34 (25.6)
Patients with any co-morbidities	50 (37.59)
Co-morbidity types	37.59% (50/133)
Hypertension	21 (15.78%)
Diabetes	20 (15.37%)
Bronchial asthma	9 (6.7%)
Dyslipidemia	9 (6.7%)
COPD	1 (0.7%)
Smoking status	
Yes	19(14.3)
No	110 (82.7)
Unknown	4(3.0)
Symptoms	133(99.2%)
Cough	92(69.2%)
Fever	58(43.6%)
Sore throat	34(25.6%)
Shortness of breath	32(24.1%)
Headache	21(15.8%)
Muscle-ache	19(14.3%)
Diarrhoea	11(8.3%)
Rhinorrhoea	10(7.5%)
Chest pain	9(6.8%)
Anosmia	6(4.5%%)
Fatigue	4(3.0%)
Nausea	1(0.8%)
Vomiting	1(0.8%)
Confusion	None
Symptom duration	
Mean and standard deviation	5.67 (3.19) days
Median	5 days

The age ranged from 4 to 94 years with a mean age of 43.9 (SD 15.7). The female to male ratio was 34:99. Fifty (50/133;37.59%) out of 133 patients had comorbidities. The risk factor profile indicated that 19(19/133; 14.3%) were current smokers; a smoking history was unknown in 4(4/133; 3%) patients.

Clinical features (Table 1)

One hundred and thirty two (132 of 133; 99.2%) out of the 133 patients who underwent chest radiography were symptomatic at the time of acquisition of chest X-ray. The mean duration of symptoms at initial x-ray was 5.67 days (SD=3.19). Commonest symptom was cough (92/133;69% of patients) while (58/133;43.6%) had fever. 10 patients received ICU care during the study period. Four patients included in the study succumbed to illness.

Chest imaging and reporting

A total of 217 chest X-rays belonging to the 133 patients were studied. Eighty four chest x-rays were follow up radiographs belonging to 33 of patients (33/133; 24.8%). Highest number of chest x- rays done in a single patient was 12. One hundred and seventy-five (175 of 217; 80.64%) chest X-rays were AP chest

radiographs and 42(42 of 217; 19.35%) were PA radiographs. One hundred and seventy nine (179 of 217; 82.5%) X-rays were taken within 14 days from the onset of symptoms. Discrepancies in reporting were present only in 32 out of 217 X-rays**.**

Description of Chest x-rays
Initial Chest x-rays n=133 (Table 2)

Table 2: Radiographic findings of initial CXR (n=133)

Number of normal initial X-rays			96
Number of abnormal initial X-rays			37
Number of patients with normal initial X-rays later becoming abnormal			0
Frequency of occurrence and distribution on initial abnormal chest x-rays (n=37)			
Sign	Frequency	Side	Predominant zone
Consolidation	25(67.5%)	Bilateral – 13 Right- 10 Left -2	Lower zone- 20 Middle zone -3 Upper and middle zone - 1 No zonal predominance -1
Ground glass appearance	20(54.05%)	Bilateral- 5 Right- 1 Left – 14	Lower zone -14 Middle zone-4 No zonal predominance -2
Nodules	1	Right-1	Lower zone -1
Cavities	None		
Effusions	None		
Hilar Lymph Nodes	None		

	Severity Score zero		Severity Score 1 or more		Statistics
	No.	%	No.	%	
Gender #					X2=3.91
Male	67	67.6	32	32.3	Df=1
Female	29	85.3	5	14.7	**P=0.048**
Presence of comorbidity#					X2=16.25
Yes	26	52.0	24	48.0	Df=12
(No+ not known)	70	84.3	13	15.7	**P<0.001**
Smoking#					X2=1.42
Yes	15	78.9	4	21.1	Df=1
(No + Not known)	81	71.1	33	28.9	P=0.49
Age*	Mean=40.25	SD=14.7	Mean =53.73	SD=14.6	**P<0.001**

Mean duration of symptoms at initial chest x-ray was 5.67 days. Ninety-six (96/133; 72.2%) of the initial chest x-rays were normal; 37(37/133; 27.8%) were abnormal (Table 2). Consolidation was the commonest radiographic finding seen on 25(25/133; 18.8%) of the initial chest x-rays followed by ground glass opacities seen in 20(20/133; 15.0%) (Table 2). Further, it was seen that eight (8 of 133; 6%) had both consolidation and ground glass opacities (GGO). Sixteen (16/37; 43.2%) of the abnormalities were bilateral and 26 (26/37; 70.3%) were peripheral in distribution. Predominant lower zone involvement was seen in 32 (32/37; 86.5 %). None of the patients had upper zone alone involvement. Figure 2 shows some of the radiographic findings in COVID-19.

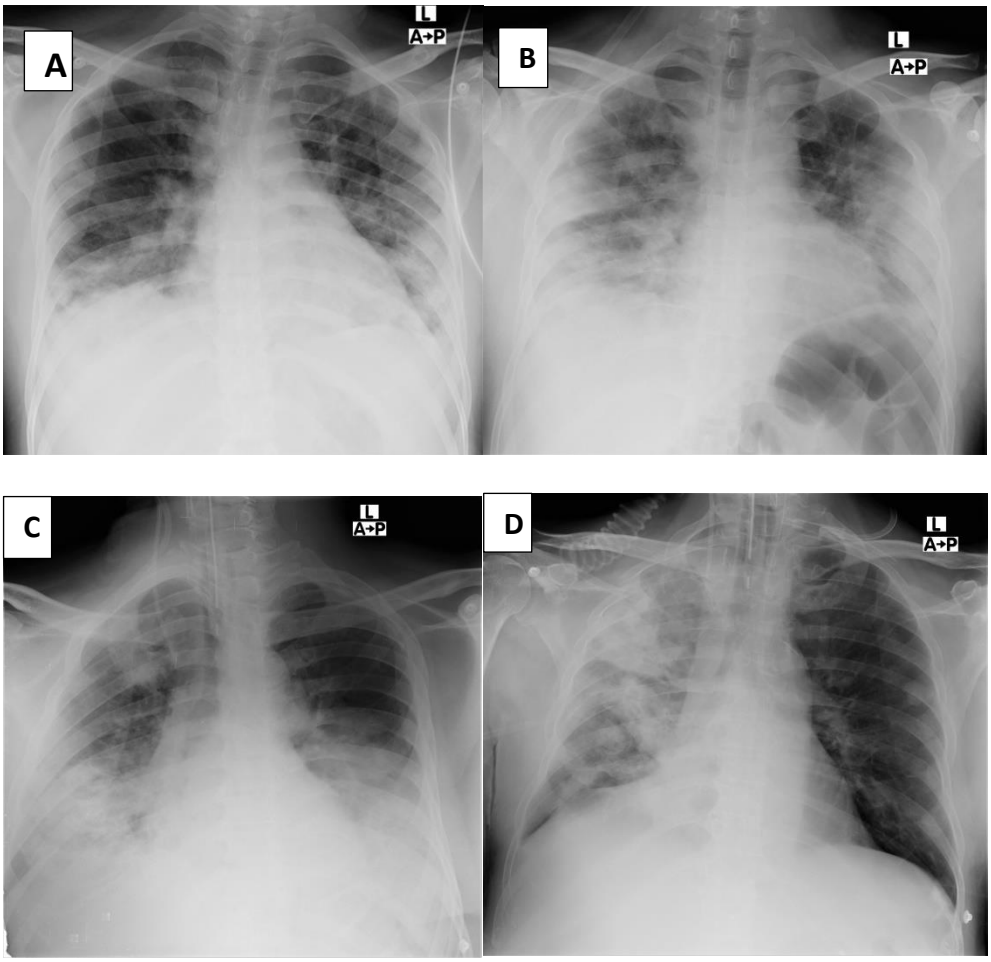

Figure 2– Chest x-ray findings of COVID-19: (A) Bilateral patchy consolidations in mid to lower zones (B) Bilateral consolidations and ground glass opacifications involving upper, mid and lower zones (C) Diffuse consolidations in bilateral lower zones (D) Asymmetrical involvement of lungs with predominantly right side involvement with consolidations and ground glass opacification.

Follow-up chest x-rays

Twelve out of the 96 patients (12/96; 12.5%) who had normal initial CXR underwent at least one follow up chest x-ray but none of those follow up chest x-rays were abnormal. Twenty one out of 37 (56.7%) patients who had abnormal initial chest x-rays had follow up CXR.

Severity scores

Severity scores of all initial x-rays (n=133), abnormal initial x-rays (n=37), all chest x-rays (n=217) were analyzed separately and the results are shown in supplementary table 1.

Figure 3 shows degree of lung involvement and changing severity scores on initial and follow up x-rays in a COVID-19 patient who recovered following ICU care.

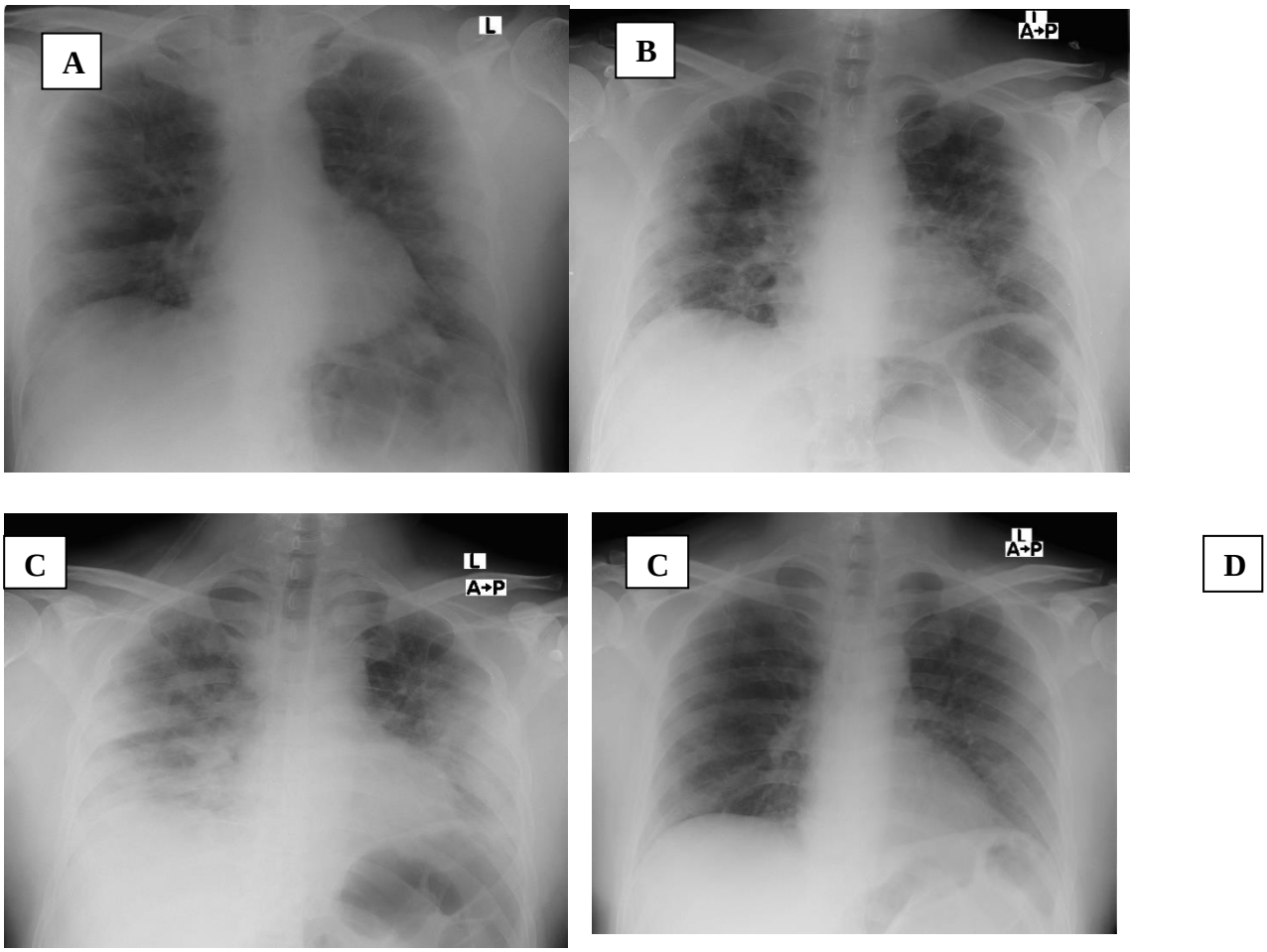

Figure 3 – Degree of lung involvement on CXR: Initial CXR and series of follow up x-rays of a COVID-19 patient who received ICU care and recovered demonstrate CXR changes along the course of illness: A- Initial chest X-ray after admission (Severity score-2); B-Follow up chest X-Ray demonstrating bilateral patchy consolidation (Severity score-6); C- Follow up chest X-ray demonstrating worsening consolidation (Severity score-8); D- Recovery phase chest X-ray (Severity score-2).

Severity score in initial x-rays- Severity scores of the 133 initial x-rays ranged from 0 to 7. Distribution of severity scores of initial x-rays was right skewed and 72.2% (96 of133) had a score of zero. Median value was also zero. Twenty-six (26/133; 19.5%) patients had mild lung involvement with a score of 1-2, while seven patients (7 of 133; 5.2%) had score of 4-7 and three (3of 133; 2.3%) had a score of 5-6 indicating more extensive lung involvement. Only one patient had a score of 7 on initial x-ray (this patient's x-ray was taken on day 5 of the illness and the patient succumbed illness). supplementary table 2

*Severity score when the highest severity for a patient was considered: (*For patients who had more than one x-ray, the chest x-ray with the highest severity score was selected for this analysis)-

The severity scores ranged from 1-8 and the results are shown in supplementary table 2.

When considering all patients (n=133): twenty one out of the 133 (21/133; 15.8%)

patients had mild lung involvement with a severity score of 1-2, while seven patients (7/133; 5.2%) had score of 3-4 and four (4/133; 3.0%) had a score of 5-6. Five patients (5/133; 3.75%) had score of 7-8 indicating disease progression on follow-up x-rays when compared to initial x-rays.

When considering only the patients with abnormal CXR (n=37): a majority of 56.75% (21/37) had only mild lung involvement with severity score of 1-2.

Relationships with the severity score

When the mean severity score of all the x-rays taken on a given day of the illness, was plotted against the duration of symptoms, it was observed that the mean severity score was highest when the duration of the illness was between the 15th-20th day. This is shown in figure 4.

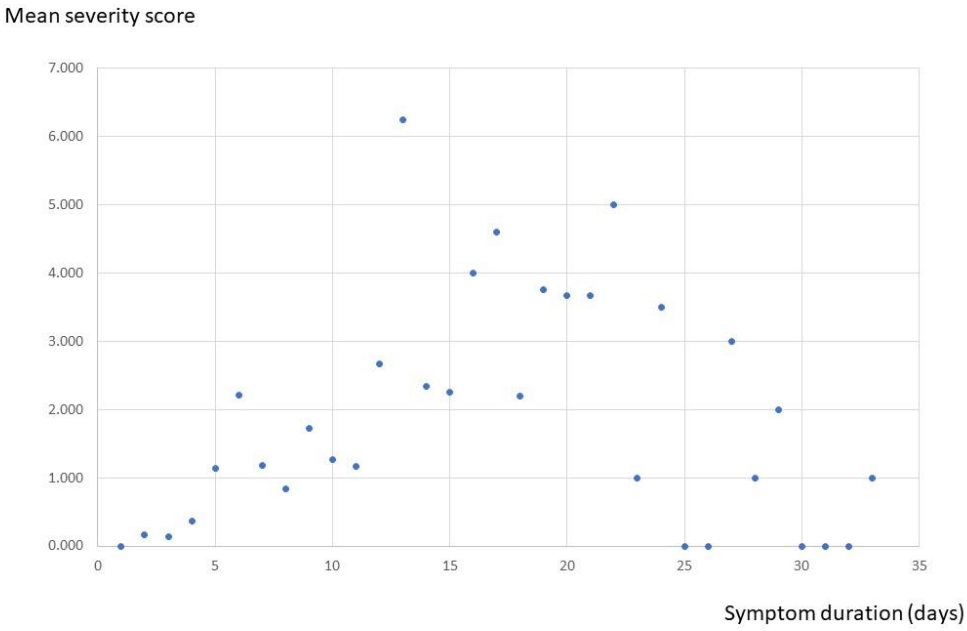

Figure 4– Mean severity score according to the duration of symptoms (n=217)

The association between the severity score of the initial chest x-rays (n=133) with gender, smoking status and comorbidities is shown in Table 3. Those with comorbidities (p<0.001), male sex (P=0.048) advancing age(p<0.001) were positively associated with a severity score o

Table 3: Sociodemographic and health related factors associated with severity score

Variable	B	df	Sig	Exp (B) (%% CI for Exp (B)

	No	%				(Lower -Upper)
Categorical Variables						
Presence of comorbidities						
Yes	50	37.6%	1.143	1	**0.019**	***3.136*** **(1.205 - 8.158)**
No	83	62.4%				Ref
Smoking status						
Yes	19	14.3%	-.862	1	0.241	0.422 (0.100- 1.782)
No	114	85.7%				Ref
Sex						
Male	99	74.4%	1.781	1	**0.008**	**5.933 (1.604-21.950)**
Female	34	25.6%				Ref
Continuous variables						
Age	133		0.054	1	**0.001**	**1.056 (1.022 -1.090)**
Duration of symptom	133		0.047	1	0.511	1.049 (0.910 -1.208)
Constant	133		-5.594	1	0.000	0.004

Chi Square analysis, * Mann Whitney U analysis

f 1 or more while the smoking status did not show a significant relationship.

Table 4 shows that in the multivariate analysis the significant relationships were retained and showed that a severity score of 1 or more was associated with presence of comorbidities (OR= 3.14), male sex (OR= 5.93) and increasing age (OR= 1.06).

Table 4: Logistic Regression analysis of severity score

Variable			**B**	**df**	**Sig**	**Exp (B)** **(%% CI for Exp (B)**
	No	**%**				**(Lower -Upper)**
Categorical Variables						
Presence of comorbidities						
Yes	50	37.6%	1.143	1	**0.019**	***3.136*** **(1.205 - 8.158)**
No	83	62.4%				Ref
Smoking status						
Yes	19	14.3%	-.862	1	0.241	0.422 (0.100- 1.782)
No	114	85.7%				Ref
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Male	99	74.4%	1.781	1	**0.008**	**5.933 (1.604-21.950)**
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Duration of symptom	133		0.047	1	0.511	1.049 (0.910 -1.208)
Constant	133		-5.594	1	0.000	0.004

B – regression coefficient, df= degrees of freedom, Exp (B)=Exponential B indicating the adjusted odds ratio

Discussion

Role of CXR in COVID-19 was widely discussed from the inception of the COVID-19 pandemic(8,9): although the sensitivity of CXR is reported to be low by many (2,3), some premier professional bodies recommended CXR as the first line imaging modality in COVID-19 (10).
The present study looked at chest radiographs of 133 RT–PCR positive COVID-19 patients during the first wave of the COVID-19 pandemic in Sri Lanka, at a time when the case fatality rate of the country was well below the reported global rate.

Many studies conducted world wide during the first waves of the pandemic, found that majority of CXRs were abnormal in patients with COVID -19 (11)(12)(13)(14). Interestingly, in the present study, the majority (72.2%) of CXRs of RT- PCR positive COVID-19 patients were normal. This finding is further highlighted, as, except for one patient, all patients included in our study had symptomatic COVID-19 infection. Furthermore, none of the follow up CXRs of those patients with normal initial CXR later became positive. Contrastingly, a study done in China by Wong et al found 79.6% (51/64) of the patients with RT-PCR positive COVID -19 to have abnormal chest x-rays even when only 86% of the patients were symptomatic(11). Similarly analysis of 240 patients with COVID-19 pneumonia by Vancheri et al revealed as many as 75% of CXR to be abnormal(12).

On severity score assessment, we found that the majority (21/37; 56.75%) of the patients with abnormal CXRs had mild lung involvement (severity score of 1-2) even when their x-rays with worst lung involvement (highest severity score) were considered. This is yet again different to the findings of Wong et al, where even at baseline chest x-ray, only 41%(26/64) had mild lung involvement. Differences in the age distribution and associated co morbidities of the two study populations may have played a role in differences in disease severity. The mean age of patients in the present study was 43.9 years as compared to mean age of 56 years in the study by Wong et al. Also, the frequency of occurrence of comorbidities were different in the two study groups: 5.37% had diabetes and 15.78% had hypertension in this study, while 13% had diabetes and 20% had hypertension in the study by Wong et al(11).

Our findings of normal or mild servery CXR in the majority, could also indicate that our study population was less affected by the infection during the first COVID-19 wave in Sri Lanka: the study setting was named WHO category 3 COVID-19 transmission phase with clustered cases only and no community transmission during the study period (15); national case fatality rates around 0.4% (well below the global rate 3.75%) was reported up to August 2020(16) in Sri Lanka.

Our study shows concurrence with current literature that consolidation and ground glass attenuation, are the commonest CXR features in patients with COVID-19(10,13,14). The worst lung involvement, as indicated by highest CXR severity scores, was observed during the second week of illness in concurrence with Wong *at al* (11). Advancing age, presence of comorbidities and male sex showed a positive correlation with a severity score of 1 or more in the present study.

The present study has number of limitations. The findings of this study could not be verified with CT or clinical severity. The study did not investigate into clinical severity and severity assessment by X-ray alone may have underestimated the actual lung involvement due to lower

sensitivity of chest x-rays (13). Also, some patients were not followed up to complete recovery as data was collected only up to 15th May2020. The x-rays were acquired as computed radiography instead of digital x-rays.

Conclusion

In conclusion, majority of the patients with RT-PCR positive COVID-19 in the present study, conducted during the first wave of the COVID -19 pandemic in Sri Lanka, had normal chest x-rays and majority of patients with abnormal CXRs had only mild lung involvement on chest radiographs. Correlation with clinical severity is warranted to make further conclusions, and further studies in the second and third waves of the pandemic are warranted.

Declaration of Conflicting Interests: 'None declared'.

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