ORIGINAL RESEARCH PAPER

Radiology

DISTRIBUTION AND ANALYSIS OF CHEST RADIOGRAPHIC FINDINGS IN COVID-19 POSITIVE SYMPTOMATIC AND ASYMPTOMATIC PATIENTS – ANALYSIS OF 668 PATIENTS IN INDIA

KEY WORDS: Chest radiograph, Covid 19, rale score, Ground glass opacity, Computed tomography

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ABSTRACT

Current COVID-19 radiological literature is dominated by CT and a detailed description of chest x-ray (CXR) appearances in relation to the disease time course is lacking. However, it poses a great challenge on the radiology department, as it is difficult to decontaminate entire CT suite(Zhao et al., 2020)11. This study is aimed to correlate clinical symptoms with the chest X-ray findings in COVID positive patients and to calculate the sensitivity and specificity of chest x ray in diagnosing COVID 19. The present study compares frequency and distribution of chest radiographic findings in COVID 19 positive symptomatic and asymptomatic patients. Patients with a RT-PCR-positive results for COVID 19 infection were 668. Of these, 437 were males (65.4%), 230 females (34.4%) and 1 transgender (0.04%) with a mean age of 44 years (range 2–87 years). Only 18 CXRs were negative for radiological thoracic involvement (6.4%) among symptomatic patients (280). Among the baseline CXR of 668 patients, 375 (56.1%) were normal and 293 (43.8%) were abnormal. Sensitivity and specificity of CXR were 93.91% and 93.3% respectively. Positive and negative predictive values were 90.97% and 95.51% respectively. We found a statistically significant relationship between CXR severity score and age, symptoms, death (P<0.001). We even found significant relationship between age and symptoms, death of COVID positive patients (P<0.001). The relationship between CXR severity and gender, age and gender were not significant (P=0.539, P=0.864 respectively).

1. INTRODUCTION

In December 2019, Wuhan City (Hubei Province, China) reported a febrile respiratory tract illness of unknown origin in a cluster of patients. Bronchoalveolar lavage of the patients isolated a novel strain of coronavirus (SARScoronavirus-2 [SARS-CoV-2]) as the pathogen (1) . The pulmonary infection caused by SARS-CoV-2 was named coronavirus disease 2019 (COVID-19) by the World Health Organization (WHO).

As on 31th January 2020, a total of 9720 confirmed cases and 213 deaths have been reported in China. The epicentre of the outbreak was initially in Wuhan City, Hubei province but has rapidly extended to all other provinces of China. On 30 January 2020, a laboratory confirmed case of 2019-nCoV was reported in Kerala.sr1 As on 2nd August 2020, 08:00 IST there were 567,730 Active Cases 1,145,629 Cured/Discharged, 1 Migrated and 37,364 Deaths in India. India's Case Fatality Rate (CFR) is its lowest at 2.15% since 1st Lockdown.

2. MATERIALS AND METHODS

2.1 SETTING

This is a prospective study of analyzing chest radiographs of RT- PCR positive COVID patients in GSL Medical College and General Hospital, Rajahmundry, East Godavari district of Andhra Pradesh.

2.2 PATIENTS AND DESIGN

Sample size – 668 patients who tested positive for COVID 19 by RT-PCR.

Symptomatic patients include patients with low grade fever (37-38C), high grade fever (>=38C), cough, hemoptysis, sore throat, diarrhea, chest discomfort and dyspnea.

Inclusion criteria

1. COVID 19 RT-PCR positive patients of all ages and gender admitted to GSL Medical College and General Hospital, Rajahmundry.
2. Both symptomatic and asymptomatic patients.
3. COVID positive patients with other comorbidities.

Exclusion criteria

1. Respiratory illness other than COVID 19.
2. COVID suspect cases who are symptomatic but RT-PCR negative.

2.3 CHEST RADIOGRAPHS

Chest radiographs of all confirmed COVID positive patients were obtained with GE 100 mA portable x-ray machine. CXR's were acquired in the postero-anterior (PA) or antero-posterior (AP) projections.

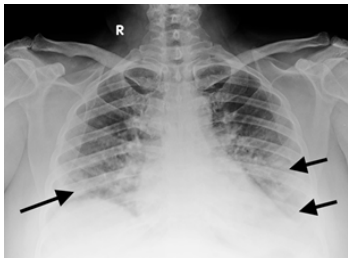
Base line radiographs were taken for every individual at the time of admission. Serial radiographs were obtained for some of the symptomatic patients to know the progression of the disease. CXR was performed for every patient after the patients tested negative, before being discharged from the hospital.

2.4 DATA COLLECTION AND ANALYSIS

Base line radiographs were taken for every individual at the time of admission after positive confirmation of COVID test. Serial radiographs are obtained in some of the symptomatic patients to know the progress of the disease.

Scoring is given for each CXR in consensus for: consolidation, ground glass opacity (GGO), location and pleural fluid.

Fig 1: Ground glass haziness in right lower and left mid and lower zones (R lung score + L lung score = total score) 1 +1 = 2



A severity index was determined for each lung. The lung scores were summed to produce the final severity score (Modified RALE score)8. (Zhao et al., 2020) A score of 0-4 was

assigned to each lung depending on the extent of involvement by consolidation or GGO (0 = no involvement; 1 = <25%; 2 = 25-50%; 3 = 50-75%; 4 = >75% involvement)10. The scores for each lung were summed to produce the final severity score. Examples for calculating score is described in fig 1 to 4.

fig 2 : ground glass haziness and consolidations in bilateral mid and lower zones (2+2 = 4)

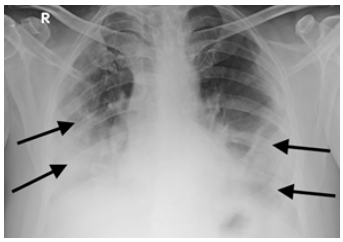


Fig 3: ground glass opacities in bilateral lung fields with mild reticulonodular appearance. (3+2 = 5)

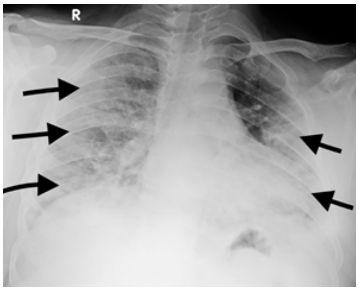
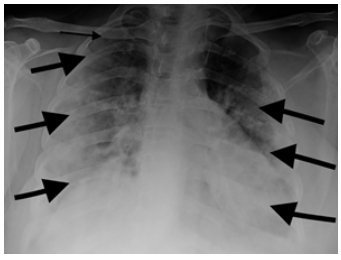


Fig 4 diffuse ground glass and consolidations in right upper, mid and bilateral lower zones (4+3 = 7)



3. RESULTS

3.1 ASSOCIATION BETWEEN RALE SCORE AND AGE DISTRIBUTION.

Table 1. DISTRIBUTION OF RALE SCORE AMONG AGE GROUPS

			RALE SCORE					Total
			0	1-2	3-4	5-6	7-8	
AGE GROUP	<20	Count	62	1	0	1	0	64
		% within AGECAT	96.9 %	1.6%	0.0 %	1.6 %	0.0 %	100.0 %
	21-40	Count	179	12	9	7	11	218
		% within AGECAT	82.1 %	5.5%	4.1 %	3.2 %	5.0 %	100.0 %
	41-60	Count	134	20	23	27	68	272
		% within AGECAT	49.3 %	7.4%	8.5 %	9.9 %	25.0 %	100.0 %
	61-80	Count	11	8	11	27	52	109
		% within AGECAT	10.1 %	7.3%	10.1 %	24.8%	47.7 %	100.0 %
	>81	Count	0	1	1	2	1	5
		% within AGECAT	0.0 %	20.0 %	20.0 %	40.0%	20.0 %	100.0 %
Total	Count		386	42	44	64	132	668
	% within AGECAT		57.8%	6.3%	6.6%	9.6%	19.8 %	100 .0%

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	232.212a	16	0.000
Likelihood Ratio	262.111	16	0.000
Linear-by-Linear Association	195.917	1	0.000
N of Valid Cases	668		

Highest RALE scores of 7 to 8 were predominantly in the 61- 80 years age group. Lowest RALE score was seen in less than 20 years age group, followed by 21- 40 yrs. RALE scores were generally seen to be increasing with progressing ages of the study subjects. Pearson Chi- square test presented a significant association (P<0.005) between RALE score and age.

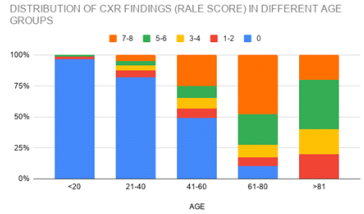


Table 2: AGE DISTRIBUTION OF DISCHARGED AND DECEASED PATIENTS

AGE	TOTAL NUMBER OF PATIENTS	DISCHARGED	DECEASED/DIED
LESS THAN 20	49	49	0
21- 40	234	222	12
41 - 60	272	191	81
61- 80	109	36	73
GREATER THAN 80	6	3	3

Majority of the admitted patients in our hospital were in the 41-60 years age group followed by 21-40 and 61-80 age groups. The percentage of discharged patients following recovery was recorded maximum in patients aged less than 20 years, followed by those aged 21-40 years.

A high rate of mortality was seen in the older age groups, in 61-80 years followed by 41-60 years.

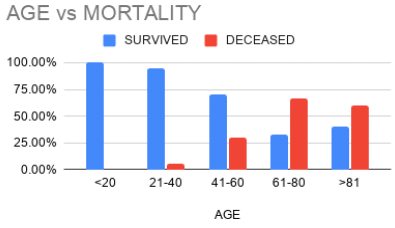
3.2 ASSOCIATION BETWEEN AGE DISTRIBUTION AND DEATH IN COVID POSITIVE PATIENTS

			DIED		Total
			NO	YES	
AGECAT	<20	Count	64	0	64
		% within AGECAT	100.0%	0.0%	100.0 %
	21-40	Count	206	12	218
		% within AGECAT	94.5%	5.5%	100.0 %
	41-60	Count	191	81	272
		% within AGECAT	70.2%	29.8 %	100.0 %
	61-80	Count	36	73	109
		% within AGECAT	33.0%	67.0 %	100.0 %
	>81	Count	2	3	5
		% within AGECAT	40.0%	60.0	100.0

Total	Count	499	169	668	
	% within AGECAT	74.7%	25.3%	100.0 %	

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	173.110a	4	.000
Likelihood Ratio	186.415	4	.000
N of Valid Cases	668		

Mortality was noted highest in the 61-80 year age group (67%), followed by >81 years age group (60%), indicating a higher death rate in the older patients, when compared to the younger subjects, where the lowest mortality was noted in patients aged <20 years. This indicated that the association between age and mortality in COVID 19 infection was significant, as evidenced by a significant p<0.005 value, which was calculated using the Pearson Chi-squared test.

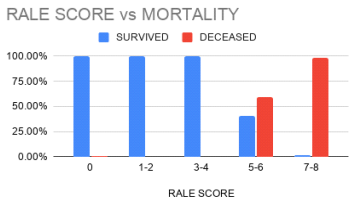


3.3 ASSOCIATION BETWEEN RALE SCORE AND DEATH IN COVID POSITIVE PATIENTS

			DECEASED		Total
			NO	YES	
RALE SCORE	0	Count	385	1	386
		% within RSCORE	99.7%	.3%	100.0 %
	1-2	Count	42	0	42
		% within RSCORE	100.0%	0.0%	100.0 %
	3-4	Count	44	0	44
		% within RSCORE	100.0%	0.0%	100.0 %
	5-6	Count	26	38	64
		% within RSCORE	40.6%	59.4%	100.0 %
	7-8	Count	2	130	132
		% within RSCORE	1.5%	98.5%	100.0 %
Total		Count	499	169	668
		% within RSCORE	74.7%	25.3%	100.0 %

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	570.615a	4	.000
Likelihood Ratio	634.546	4	.000
N of Valid Cases	668		

High rale scores of 7-8 was associated with maximum mortality with 98.5% of the cases with a score of 7-8 succumbing to the disease. This was followed by a RALE score of 5-6, with 59.4 % of the cases presenting with 5-6 score range succumbing to COVD 19. This showed that there was an association between RALE score and death in COVID positive patients, which was found highly significant with a Pearson Chi-squared p-value less than 0.005.



3.4 ASSOCIATION BETWEEN AGE AND GENDER IN COVID POSITIVE PATIENTS

			GENDER			Total
			F	M	T	
AGECAT	<20	Count	28	36	0	64
		% within AGECAT	43.8%	56.3%	0.0%	100.0 %
	21-40	Count	65	153	0	218
		% within AGECAT	29.8%	70.2%	0.0%	100.0 %
	41-60	Count	95	176	1	272
		% within AGECAT	34.9%	64.7%	.4%	100.0 %
	61-80	Count	41	68	0	109
		% within AGECAT	37.6%	62.4%	0.0%	100.0 %
	>81	Count	1	4	0	5
		% within AGECAT	20.0%	80.0%	0.0%	100.0 %
Total		Count	230	437	1	668
		% within AGECAT	34.4%	65.4%	.1%	100.0 %

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.977a	8	.539
Likelihood Ratio	7.314	8	.503
N of Valid Cases	668		

The age and gender distribution of the cases included in the study are presented in the above table. In general, more males with COVID 19were admitted to the hospital than females in each of the age group category. However this relation between age and gender was found to be of no significance when evaluated using the Pearson Chi-squared test (p-value more than 0.005). The number of males and females admitted to our hospital was highest in the 41-60 years of age group.

3.5 ASSOCIATION BETWEEN RALE SCORE AND GENDER IN COVID POSITIVE PATIENTS

			GENDER			Total
			F	M	T	
RSCORE	0	Count	135	250	1	386
		% within RSCORE	35.0%	64.8%	.3%	100.0 %
	1-2	Count	18	24	0	42
		% within RSCORE	42.9%	57.1%	0.0%	100.0 %
	3-4	Count	14	30	0	44
		% within RSCORE	31.8%	68.2%	0.0%	100.0 %
	5-6	Count	24	40	0	64
		% within RSCORE	37.5%	62.5%	0.0%	100.0 %
	7-8	Count	39	93	0	132
		% within RSCORE	29.5%	70.5%	0.0%	100.0 %

Total	Count	230	437	1	668
	% within RSCORE	34.4%	65.4%	.1%	100.0 %

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.918a	8	.864
Likelihood Ratio	4.273	8	.832
No of Valid Cases	668		

The distribution of males and females according to their COVID-CXR presentation is depicted in the above table. The table shows that RALE score in women was mostly in the range of 1-2, making for in 49.3% of the cases presenting with a score of 1-2. The RALE score in men was higher, with 70.5% of the cases presenting with a score in the range of 7-8 being males. However, no significant association was found between the RALE score and gender when evaluated using the Pearson Chi-squared test (p-value more than 0.005)

3.6 SENSITIVITY AND SPECIFICITY OF CHEST XRAY IN COVID POSITIVE SYMPTOMATIC AND ASYMPTOMATIC PATIENTS

Out of 668 cases included in this study, 56.1% of the patients showed no significant findings in chest radiographs, and positive findings were recorded in 43.8% of the cases.

BASE LINE CXR	NUMBER OF PATIENTS	PERCENTAGE OF PATIENTS (%)
NORMAL	375	56.1
ABNORMAL	293	43.8

In cases presenting with symptoms, distribution of CXR findings in symptomatic and asymptomatic cases is as mentioned in the following table. Analysis of the table has resulted in the following observations.

- Sensitivity of chest radiographs in diagnosing COVID 19 positive patients is 93.91%.
- Specificity of chest radiograph in diagnosing COVID 19 positive patients 93.3%.
- Positive predictive value is 90.97%, negative predictive value is 95.51%.
- Accuracy is 93.55%
- Positive likelihood ratio is 14.01%.
- Negative likelihood ratio is 0.07%.

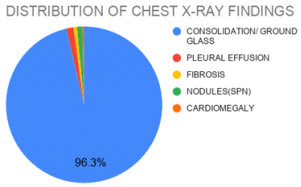
CXR	SYMPTOMATIC	ASYMPTOMATIC
POSITIVE	262(TP)	26(FP)
NEGATIVE	18(FN)	362(TN)

3.7 DISTRIBUTION OF CHEST XRAY FINDINGS IN COVID POSITIVE PATIENTS

LUNG DISTRIBUTION	PERCENTAGE OF PATIENTS
Peripheral	57.5
Perihilar	20.5
Diffuse	73.6
Basal predominance(lower zone)	40.7
Superior predominance (upper zone)	4

Diffuse distribution is seen 73.6% of patients followed by basal and peripheral predominance i.e. 40.7 and 57.5% respectively

CXR FINDING	NUMBER OF PATIENTS
CONSOLIDATION/ GROUND GLASS	261
PLEURAL EFFUSION	4
FIBROSIS	2
NODULES(SPN)	3
CARDIOMEGALY	1



RESULTS

Patients with a RT-PCR-positive results for COVID 19 infection were 668. Of these, 437 were males (65.4%), 230 females (34.4%) and 1 transgender (0.04%) with a mean age of 44 years (range 2–87 years). Only 18 CXRs were negative for radiological thoracic involvement (6.4%) among symptomatic patients (280). Among the baseline CXR of 668 patients, 375 (56.1%) were normal and 293 (43.8%) were abnormal. Sensitivity and specificity of CXR were 93.91% and 93.3% respectively. Positive and negative predictive values were 90.97% and 95.51% respectively. We found a statistically significant relationship between CXR severity score and age, symptoms, death (P<0.001). We even found significant relationship between age and symptoms, death of COVID positive patients (P<0.001). The relationship between CXR severity and gender, age and gender were not significant (P=0.539, P=0.864 respectively).

HIGHLIGHTS

- Patients with consolidations and GGO coexisting in the same radiography were 261(96%) of total.
- Peripheral (57.5%) and lower zone distribution (40.7%) were the most common predominance.
- Given the results, baseline CXR sensitivity as reported in our study is about 93.6% and specificity about 92.78%.
- Bilateral involvement (87.1%) was most frequent than unilateral.

4. DISCUSSION

Coronaviruses are a large family of viruses which are known to cause respiratory disease. They cause illnesses which range from the common cold to more severe diseases, such as Middle East Respiratory Syndrome which is MERS, or SARS which is Severe Acute Respiratory Syndrome.

We know that viruses continue to emerge and they pose challenges to public health. Some of these examples are: Severe Acute Respiratory Syndrome coronavirus (SARS-CoV), which emerged in 2002 in China; the 2009 H1N1 influenza, which turned out to be a pandemic; the 2012 Middle East Respiratory Syndrome coronavirus (MERS-CoV) which first emerged in Saudi Arabia; and now, we have a novel coronavirus, the 2019 novel coronavirus (COVID-19) which emerged in China in 2019.

4.1 IMAGING IN COVID -19:

Radiographs, CT and ultrasound play a key role in diagnosis of COVID 19, along with RT – PCR and other microbiological investigations. Though CT is more specific than x-rays for screening, it is not cost efficient and cannot be used for follow-ups for already positive patients, as it goes against ALARA principle and poses a radiation risk to the general population.

COMPUTED TOMOGRAPHY IN COVID-19

Known features of COVID-19 on initial CT include bilateral multi-lobar ground-glass opacification (GGO) with a peripheral or posterior distribution, mainly in the lower lobes and less frequently within the right middle lobe. Atypical initial imaging presentation of consolidative opacities superimposed on GGO may be found in a smaller number of cases, mainly in the elderly population. Septal thickening, bronchiectasis, pleural thickening, and subpleural involvement are some of the less common findings, mainly in

the later stages of the disease. Pleural effusion, pericardial effusion, lymphadenopathy, cavitation, CT halo sign, and pneumothorax are uncommon but may be seen with disease progression. Follow-up CT in the intermediate stage of disease shows an increase in the number and size of GGOs and progressive transformation of GGO into multifocal consolidative opacities, septal thickening, and development of a crazy paving pattern, with the greatest severity of CT findings visible around day 10 after the symptom onset5

CHEST XRAY IN COVID 19

Most common findings of COVID 19 in chest radiographs are ground glass opacities and consolidations predominantly in bilateral lower zones with basal and peripheral predominance, as well as reticular nodular thickening. Less common findings include pleural effusion, fibrosis, nodules, and masses. Here in our study we had 96% of positive and symptomatic patients with ground glass/consolidations. Rest of the findings are seen in remaining 4% of the patients. In this current study, we have demonstrated that the common CT findings of bilateral involvement, peripheral distribution, and lower zone dominance can also be appreciated on CXR.

4.2 RALE SCORE

To quantify the extent of infection, a severity score was calculated by adapting and simplifying the Radiographic Assessment of Lung Edema (RALE) score proposed by Warren et al[8].

A score of 0-4 was assigned to each lung depending on the extent of involvement by consolidation or GGO (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[10]

2. CONCLUSION

We conclude that chest x-rays in establishing a diagnosis and assessing the severity of COVID 19 infection was useful, significant and it can be used as a tool for general screening and follow-up. It is also safer than CT when the principle of ALARA is to be taken into consideration.

In this study, in addition to evaluating associations of radiographic findings with parameters such as age, gender, mortality and a scoring system, we have also described the features of COVID 19 on CXR to complement the existing publications on radiographic and CT findings in COVID 19. As the COVID-19 pandemic threatens to overwhelm healthcare systems worldwide, CXR may be considered as a tool for identifying COVID-19, but with lesser sensitivity than CT.

Limitations of the study: This study was conducted in India during the ongoing pandemic period from April to August 2020, and a shift in the presentation of patients admitted to our general hospital from asymptomatic to symptomatic was noted. This may have caused a selection bias. Also, as we have not compared the chest radiographs with CT scans of the subjects, due to which early pulmonary changes may have been missed/misinterpreted.

6.ACKNOWLEDGEMENTS: NIL

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