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Original Research Article

COVID-19: HRCT lung pattern, distribution and severity score with clinico-pathological correlation in a tertiary level institution in rural Maharashtra

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ABSTRACT

Background: The severe acute respiratory syndrome corona viruses 2 (SARSCoV-2) are enveloped positive sense RNA virus. Most patients of coronavirus disease 2019 (COVID-19) show fever, cough, dyspnoea and myalgia with weakness.
Methods: In this retrospective cross-sectional study 502 patients who were RT-PCR positive for COVID-19 participated in our study after informed consent was taken from all patients, during the period of 3 months between July to September 2020. The study was conducted in Department of Radiodiagnosis at Krishna Institute of Medical Sciences in karad. Each HRCT-Lung scan was evaluated for distribution (central or peripheral); findings (like ground glass opacities, interlobular septal thickening). Every lobe was then allotted CT severity score.
Results: The threshold cut-off value for HRCT severity score was found to be 8. The parameters achieved with this cut-off value were: sensitivity – 100%, specificity- 95.15%, positive predictive value- 85.7%, negative predictive value – 100%. On application of pearson correlation coefficient between HRCT severity score and pathological parameters, it was found that strongest correlation was found to be with D-dimer values (0.833), then with ESR (0.484) and least with N/L (neutrophil/lymphocyte) ratio (0.350).
Conclusions: On imaging, HTCT thorax showed most common involvement to be peripheral, ground glass opacity and crazy paving being most common findings. The most common finding being left and right lower lobe. The ROC curve showed the CT severity score corresponding to clinical severity to be 8. Among pathological parameters, the strongest correlation with CT severity score was found to be with D-dimer.

Keywords: COVID-19, HRCT, D-dimer, CT severity score

INTRODUCTION

The severe acute respiratory syndrome corona viruses 2 (SARSCoV-2) are enveloped positive sense RNA virus, measuring about 60-140 nm in diameter and under electron microscope shows spike like projections on its surface giving it a crown like appearance. There are four corona viruses which have been identified circulating in humans, namely HKU1, NL63, 229E and OC43. The virus was seen to have more than 95% homology with bat coronavirus sequence RaTG3, which suggested zoonotic origin. It was seen to be isolated and cultured in human respiratory epithelial cells in about 96 hours and 6 days in Vero E6 and Huh-7 cell lines. The R0 for the corona virus was estimated at 3.77.

SARSCov-2 cases were first seen in Wuhan, capital city of Hubei province, People's republic of China in December 2019, with most cases tracing back to Huanan wholesale

seafood market.[1] On 31st December, 2019 china notified the outbreak to World Health Organization (WHO), on 1st January the Huanan seafood market was closed. On 7th January the virus was found to have homology with bat coronavirus. The first fatality was reported on 11th January, 2020. With Chinese New Year around the corner, the cases were soon seen spreading to other countries as well, thus indicating human to human transmission. On 12th February, 2020 the International Committee on Taxonomy of Viruses declared the official classification to be severe acute respiratory syndrome corona viruses 2 (SARSCoV-2), on the same day WHO announced that the disease caused by the virus to be corona disease 2019 (COVID-19).[2]

COVID-19 has shown rapid rate of transmission which has made the disease pandemic, with around 96,45,544 confirmed cases found in India alone till 05th December, 2020. The rapid spread of the disease suggests person to person transmission. Factors complementing the rapid spread are duration of incubation period (up to 14 days), infectiousness peaking on or before symptom onset and nature of initial dormancy of symptoms.[2]

Most patients of COVID-19 show fever, cough, dyspnoea and myalgia with weakness. Post COVID complications include acute respiratory distress syndrome (ARDS), pneumonia, kidney failure, bacterial superinfections, coagulation abnormalities and thromboembolic events. Factors associated with poor outcome and increased risk of mortality are hypertension, diabetics, cardiovascular diseases, sex and obesity. Also, older age group are found to be at greater risk probably because of decrease in immune function and increased production of type 2 cytokines, both of which are responsible for prolonged proinflammatory response. Men are also found to be more susceptible the disease due to genetic polymorphism, smoking, pre-existing comorbidities and expression of angiotensin-converting enzyme 2 (ACE 2).[1]

The patients were described as severe on any of the following criteria's 4 - Respiratory rate of more than 30 breaths per minute. Finger of oxygen saturation of 93% or less in resting stage. Arterial oxygen tension (PaO2)/ inspiratory oxygen fraction (FiO2) of 300mm of Hg or less. Respiratory failure and mechanical ventilation required. Patient in shock or other organ failure leading to intensive care unit monitoring and treatment.

Pathological parameters which are seen to be mainly deranged are interleukin 6 (increase in which can lead to acute severe systemic inflammatory response syndrome-SIRS, known as 'cytokine storm'), d-dimer (increase in which has been seen to increase 28-mortality among patients admitted to ICU), and lactate dehydrogenase along with lymphopenia and increase in C-reactive protein.[1]

Radiological lesions were described and diagnosed based on the Fleischner Society glossary of terms as ground glass opacities, interlobular septal thickening, crazy paving, consolidation, subpleural bands, tractional bronchiectasis and vascular dilation.[3]

METHODS

In this retrospective cross-sectional study 502 patients who were RT-PCR positive for COVID-19 participated in our study after proper consent was taken from each. This study was conducted at radiology department of Krishna Institute of medical Sciences, Karad from May, 2020 to August, 2020.

Clinically the patients were classified as severe or mild on admission based on above criteria, their symptoms were then noted and associated signs examined. Proper history for co-morbidities were taken. Pathological parameters were sent for each patient on 3rd day of admission and neutrophil/lymphocyte ratio was calculated, also D-dimer and ESR values were noted for every patient. CT scan was done for each patient on 5th day of their onset of symptoms. CT scan was done using 16-row multidetector scanner (Siemens SOMATOM emotion), with following parameters: kVp – 130; Effective mAs – 73; pitch – 1.4; sharp kernel – B90s very sharp; slice thickness – 5 mm; reconstruction FOV – 348 mm with centre X – 20 mm, Y – 0 mm; Kernel – T20f standard, rotation time – 0.6s; scan time – 13.9 s with delay of 4s; direction of scan – cranio-caudal; CTDi Volume – 8.35 mGy*cm; DLP – 258.51 mGy*cm and high spatial resolution algorithm.

4 radiologists who were blinded to the clinical and pathological data evaluated the CT findings in consensus. Each scan was evaluated for distribution – central or peripheral; findings - ground glass opacities, interlobular septal thickening, crazy paving, consolidation, subpleural bands, tractional bronchiectasis and vascular dilation. Every lobe was then allotted CT severity score. The CT severity score was assigned on the basis of percentage of involvement – The data acquired was then evaluated with the Statistical package for social sciences (SPSS) version: V27 and chi-square test, unpaired t test and ROC were calculated according to the available data and relevant statistics were calculated.

RESULTS

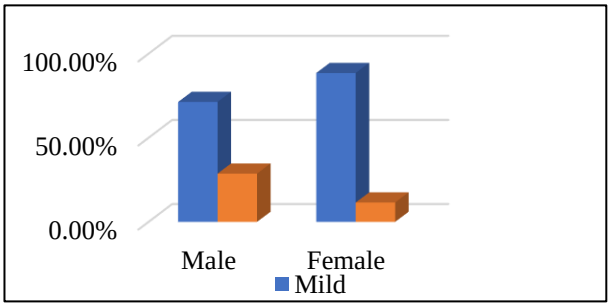

Figure 1: Gender distribution according to Clinical severity.

Table 1: CT Severity score according to percentage of involvement.

Involvement (in %)	CT severity score
0	0
0 to 10	1
11 to 20	2
21 to 30	3
31 to 50	4
51 to 100	5

Table 2: Age distribution according to clinical severity.

Clinical stage	N	Minimum	Maximum	Mean	Std. deviation
Mild	388	9.00	86.00	39.5670	15.30324
Severe	114	28.00	85.00	51.5965	13.11469

Table 3: Pathological parameters.

Clinical stage		NL_Ratio	D_dimer	ESR
Mild	N	388	388	388
	Minimum	0.75	0.04	1.00
	Maximum	11.25	3.37	120.00
	Mean	2.7068	0.2604	31.2784
	Std. Deviation	1.60876	0.37024	25.57120
Severe	N	114	114	114
	Minimum	0.90	0.54	5.00
	Maximum	8.80	3.00	130.00
	Mean	4.1840	0.9727	60.4386
	Std. Deviation	1.94302	0.45800	33.65994
Unpaired t test	t test value	8.204	17.066	9.915
	p value	<0.001	<0.001	<0.001

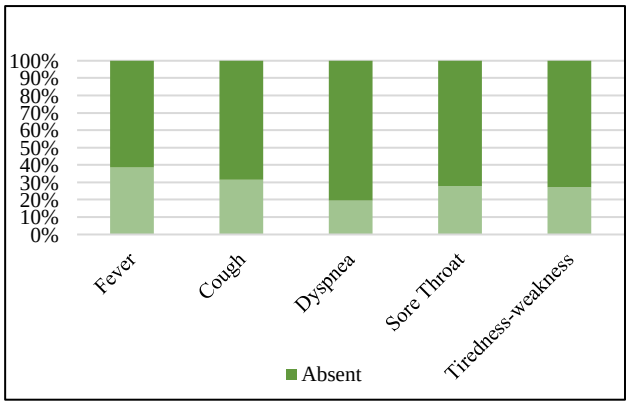

Figure 3: Distribution of clinical features.

DISCUSSION

Out of 502 patients, 77.3% (388) presented symptoms which was classified as mild and 22.7% (114) patients presented with symptoms which were classified as severe. Among these, 328 patients were male, in which 28.7% (94) showed clinically severe symptoms, and out 174 female patients only 11.5% (20) presented with clinically severe symptoms. Chi-square test was used and the p value for same was significant (<0.001).[2,3]

Table 4: Comparison between X ray and HRCT findings.

		HRCT		
		Normal	**Abnormal**	**Total**
X ray	Normal	114	225	339
		33.6%	66.4%	100.0%
		93.4%	59.2%	67.5%
	Abnormal	8	155	163
		4.9%	95.1%	100.0%
		6.6%	40.8%	32.5%
Total		122	380	502
		24.3%	75.7%	100.0%
		100.0%	100.0%	100.0%

Table 5: HRCT Distribution among all patients

	Peripheral distribution		Central distribution	
	Frequency	**Percent**	**Frequency**	**Percent**
Absent	132	26.3	330	65.7
Present	370	73.7	172	34.3
Total	502	100	502	100

Table 6: Cross tabulation of HRCT distribution pattern.

			CT peripheral		Total
			Absent	**Present**	
CT Central	Absent	Count	16	194	210
		% of Total	4.2%	51.1%	55.3%
	Present	Count	6	164	170
		% of Total	1.6%	43.2%	44.7%
Total		Count	22	358	380
		% of Total	5.8%	94.2%	100.0%

Table 7: HRCT findings.

	Present		Absent	
	Frequency	**Percent**	**Frequency**	**Percent**
Ground glass opacity	334	87.9	46	12.1
Interlobular septal thickening	176	46.3	204	53.7
Crazy paving	184	48.4	196	51.6
Consolidation	164	43.2	216	56.8
Sub pleural bands	150	39.5	230	60.5
Tractional bronchiectasis	24	6.3	356	93.7
Vascular dilation	40	10.5	340	89.5

Table 8: ROC severity and clinical stage correlation.

Count				
		Clinical stage		Total
		Severe	**Mild**	
ROC_Severity2	Severe (Score>8)	114	19	133
	Mild (Score<=8)	0	369	369
Total		114	388	502

Specificity- 95.15%; positive predictive value- 85.7%, negative predictive value – 100%. Overall correct prediction value of HRCT severity score with threshold cut-off value of 8 – 96.2%.

Among patients classified clinically as mild, 60.3% (234) were male patients, whereas among clinically severe patients 65.3% (328) were male patients.[3,4] The mean age of patients in clinically mild category was 39.6 with standard deviation of 15.3, and 51.6 with standard deviation of 13.1 in clinically severe category. Unpaired T-test was applied for same and p value was found to be significant (<0.001).[3-7]

Table 9: CT severity and pathological parameters correlation.

		NL_Ratio	D_dimer	ESR
Severity	Pearson Correlation	0.350**	0.833**	0.484**
	Sig. (2-tailed)	0.000	0.000	0.000

The most common symptom with which patients presented was fever in 38.6% (194), followed by cough- 31.5% (158), sore throat- 27.9% (140), tired and weakness- 27.1% (136), dyspnoea- 19.5% (98), myalgia- 7.6%, headache- 5.6%, rhinorrhea- 4.4% (22), loss of smell- 2.8%, loss of taste- 2.4%, dizziness- 0.8% and diarrhoea- 1.6%.[6-8] Hypertension was the most common co-morbidity with which the patients presented and was seen in 17.1% of them, where as diabetes was seen in 12.4%. About 14.3% patients presented with other co-morbities.[8]

In our present study three pathological parameters were taken for all the participating patients- neutrophil/lymphocyte ratio (N/L ratio), D-dimer and ESR

values. The mean N/L ratio for clinically mild category was 2.7 with standard deviation of 1.6 and 4.2 with standard deviation of 1.9 in clinically severe category. The relation was statistically significant on unpaired T-test with $p<0.001$.[9,10]

The mean D-dimer ratio for clinically mild category was 0.26 with standard deviation of 0.37 and 0.97 with standard deviation of 0.45 in clinically severe category. The relation was statistically significant on unpaired T-test with $p<0.001$.[9]

The mean ESR ratio for clinically mild category was 31.3 with standard deviation of 25.6 and 60.4 with standard deviation of 33.6 in clinically severe category. The relation was statistically significant on unpaired T-test with $p<0.001$.

All patients in our study had done their chest radiographs and HRCT thorax during their stay in hospital. The imaging done between 5th to 9th day was taken in consideration for our present study. Among these 502 patients, 32.5% (163) of them showed abnormality on their chest radiographs, whereas 75.7% (380) showed COVID-19 pneumonitic changes on HRCT thorax scan.[3,6,7,11,12]

Out of 163 abnormal chest radiographs, 95.1% (155) also showed COVID-19 pneumonitis changes on HRCT throax, where as in 4.9% (8) chest radiograph was reported as abnormal with changes of COVID-19 pattern, but on HRCT thorax no changes were seen pertaining to COVID-19; among these 6 of these chest radiographs had minimal changes related to COVID-19 and were done on 5th or 6th day of admission, whereas HRCT thorax was performed on 9th day of admission and lungs were clear on it, which was correlating with clinical prognosis of the patient as well. 2 chest radiographs were wrongly reported with findings of COVID-19, both of them stating that the findings were seen in left lower lung zone, whereas on subsequent HRCT thorax no such finding was seen; retrospectively those findings on chest radiographs were concluded to be companion shadows.[11,12]

Among HRCT Thorax, 380 patients had abnormal scan, among which chest radiograph could only pick abnormality in 40.8% (155) cases, whereas in the rest the radiograph was reported normal.[3,13]

The abnormal findings of HRCT thorax was further studied in our study according to the area of involvement and subclassified as either central or peripheral involvement. Among all the abnormal HRCT thorax 44.7% (170) had central abnormality and 94.2% (358) had peripheral findings. The most common area of involvement in our study (in descending order) was thus – only peripheral involvement (194), both central and peripheral involvement (164) and only central involvement.[3,6,7]

The HRCT thorax abnormalities encountered in COVID-19 pneumonitis, predominantly presented with following six patterns, namely- ground glass opacity (GGO), interlobular septal thickening (IST), crazy paving (CP), consolidation (C), subpleural bands (SB), tractional bronchieactasis (TB) and vascular dilation (VD). In decreasing order these were – GGO- 87.9%, CP- 48.4%, IST- 46.3%, C- 43.2%, SB- 39.5%, VD- 10.5% and TB- 6.3% (Figure 4 A-F).[3,6,7]

According to our scoring system, scores of 0-5 were given to each lobe, according to the percentage of involvement. In our study it was found that left was more common side of involvement; the frequency of lobar involvement in descending order was- LLL- 81.8% (311), RLL- 78.4% (298), LUL- 67.9% (258), RML- 66.6% (253) and RUL- 61.6% (234) (Figure 5 A-E).[14]

The receiver operating characteristic curve (ROC) analysis was then applied to the total HRCT severity score for each patient against their clinical staging (mild or severe). The threshold cut-off value for HRCT severity score was thus found to be 8. The parameters achieved with this cut-off value were: sensitivity – 100%, i.e among the clinically severe category patients, HRCT severity score of more than 8 was able to recognise all the patients.

Specificity- 95.15%; i.e. the patients with HRCT severity score of less than or equal to 8 among clinically mild category patients.

Positive predictive value- 85.7%; i.e. patients with HRCT severity score of more than 8 also had severe clinical staging and thus were managed appropriately.

Negative predictive value – 100%; i.e. those patients who had HRCT severity score of equal to or less than 8 and were classified clinically as mild category.

Overall correct prediction value of HRCT severity score with threshold cut-off value of 8 – 96.2%.[3,6,7]

On application of pearson correlation coefficient between HRCT severity score and pathological parameters, namely D-dimer, N/L ratio and ESR: it was found that all three parameters had positive linear correlation with HRCT severity score. The strongest correlation was found to be with D-dimer values (0.833), then with ESR (0.484) and least with N/L ratio (0.350).[9,10]

Limitations of the study

Taking into account the vast and rapid number of publications coming out related to COVID-19, the finding in this paper would be quickly complimented with by further research. There is also possibility of publication bias with possibility of positive results being preferentially published. There can also be geographical bias with all the study based on from single hospital data. Moreover, the patients we considered for the following study were those

who could be mobilised to our CT scan room, thus eliminating patients who were receiving mechanical ventilation or could not be mobilised for other reasons.

CONCLUSION

Our study showed that COVID-19 was seen more commonly among male, with fever, cough and sore throat being most common symptoms. Due to constraints of our study, with patients coming for HRCT thorax, most of the patients in our study were those who were clinically mild. The most common comorbidity found among patients in our study was hypertension. On imaging, HTCT thorax showed most common involvement to be peripheral, ground glass opacity and crazy paving being most common findings. The most common finding being left and right lower lobe. The ROC curve showed the CT severity score corresponding to clinical severity to be 8. Among pathological parameters, the strongest correlation with CT severity was found to be with D-dimer.

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