Chest CT Scan Findings in Symptomatic Patients Infected with COVID-19 in Norvic International Hospital, Nepal

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ABSTRACT

Background

Coronavirus disease (COVID-19) is the recent global health emergency making it crucial for rapid diagnosis and intervention. Computed tomography (CT) is important for screening, diagnosis and evaluating severity and disease progress.

Objective

To assess the CT changes in COVID patients and study its relationship with various factors.

Method

A retrospective study was conducted at Norvic International hospital from August 2020 to November 2020 among RT-PCR positive symptomatic COVID cases who had positive CT changes. CT imaging data were analyzed by radiology expertise. Statistical analysis was carried out with the help of SPSS 16.

Result

Out of 120 patients, 75% were males and mean age was 54.70±15.56 years. The mean CT severity score was 18.35±6.87. Pure ground glass opacities was seen in 74(61.7%), reticulations 89(74.2%) and crazy-paving pattern 28(23.3%). CT scans with bilateral 118(98.3%) and peripheral involvement 109(90.8%) in all five lobes. CT- severity score was positively correlated with oxygen and mechanical ventilation requirement (P-value < 0.05 and 0.011 respectively).

Conclusion

CT findings including pure ground glass opacities, reticulations, bilateral and peripheral involvement involving all five lobes were more frequent. Our data suggest that CT-severity score significantly correlates with oxygen and mechanical ventilation requirements.

KEY WORDS

Coronavirus disease (COVID-19), Computed tomography, Ground glass opacity, Severity score

INTRODUCTION

An outbreak of coronavirus disease (COVID-19) was first reported in Wuhan, China in December 2019.[1] Above 100 million people globally have been infected until early 2021 with deaths of above two million.[2] In Nepal, there was a single COVID-19 case till January 23 which skyrocketed by the end of March.[3,4] Thus, rapid diagnosis is crucial for early management. However, rapid diagnosis is somehow challenging since the sensitivity and specificity of tests (clinical, radiological, laboratory) are highly variable.[5,6]

Thin slice computed tomography (CT) of chest is reported to be the most reliable method for assessing disease severity.[7] As reported by literature, specific chest findings include a spectrum ground glass changes, consolidation, crazy paving pattern with peripheral distribution. Other atypical findings include nodules, reticulations, subpleural curvilinear lie, halo sign, bronchial thickening and vascular enlargement.[8,9]

In addition to those features from the published literature, our study plans to find similarities and differences in chest CT findings of COVID-19 infected patients, if found any, in the Nepalese patients from the patients in other countries. In this study, we aim to report the Chest CT Scan findings in symptomatic patients infected with COVID-19 in Norvic International hospital (NIH), Nepal.

METHODS

This is a retrospective descriptive cross sectional study. Data was collected from Norvic International hospital, Thapathali which is a 150 bed, state of art, leading specialty centre established in 1994. Data was collected over a period of three months (15 August 2020 to 15 November 2020) which coincided with the first peak of COVID-19 infection in Nepal. All Chest CT scans of symptomatic COVID-19 over the study period meeting the inclusion criteria were taken in the study by purposive sampling.

All CT scans were performed on a single machine, the Philips Ingenuity 128 slice multidetector CT scanner machine. Tests were run in the Phantom on every alternate day to set the machine technical calibers in the normal standards. The HRCT images stored in database were reanalyzed by the principal investigator of this study having above 15 years of experience in the radiology department in the prepared proforma. Some variables were taken from the patient's charts in the record section.

Confidentiality of individual identification and data was strictly maintained. Administrative approval was taken from NIH (Cha na 221-077/078) and ethical approval was taken from Nepal Health Research Council (NHRC) on 11 May 2021 (Ref. no. 3096).

Inclusion criteria included the CT scans and records of patients who tested PCR positive and were admitted with symptoms of COVID-19 as per WHO guidelines for COVID diagnosis. Exclusion criteria included past or pre-existing lung or systemic illness such as Carcinoma lung, Idiopathic pulmonary fibrosis, past or active pulmonary tuberculosis, documented atypical, viral or lobar pneumonia, interstitial lung diseases, chronic inflammatory or autoimmune conditions like sarcoidosis, Wegener's granulomatosis, rheumatoid arthritis, Systemic Lupus Erythematosus, ionizing radiation to chest for intrathoracic or extra thoracic tumors, and pregnant females.

The images were evaluated for the presence or absence of following characteristics: (1) pure ground-glass opacities (GGO), (2) parenchymal consolidation, (3) combination of ground-glass opacities and consolidation, (4) reticulations (5) degree of lung involvement measured by "total severity score" (6) nodules (7) pleural effusion, (8) thoracic lymphadenopathy (defined as lymph node size of ≥ 10 mm in short-axis dimension), (9) small airways abnormalities (wall thickening, bronchiectasis, and endoluminal secretions), (10) central distribution of disease ("peribronchovascular" predominant disease) (11) number of lobes affected, and (12) Other abnormalities like opacities with a rounded morphology, linear opacities , "reverse halo" sign opacities, "crazy-paving" pattern opacities, and opacities with intralesional cavitation. All CT scans were scored on the basis of chest CT scan severity score (CT-SS assessment) where each lung is divided into 20 regions. No parenchymal opacification, parenchymal opacification less than 50%, and equal to or more than 50% of each region were assigned a score of 0, 1 and 2 respectively. Individual scores in the 20 lung segment regions were then summed to get a final CT-SS score. A cut-off CT-SS score of 19.5 was set to categorize severity. A CT-severity score of 0-19.5 was kept under low-risk group and that equal to or higher under high-risk group. Finally, correlation with different variables was done after calculating the total severity score.[10]

Data was entered in Microsoft excel analyzed using SPSS 16. Continuous data were expressed as mean and standard deviation (SD) and nominal data as frequency (%). Chi square was used to see the association and p-value less than 0.05 was considered significant statistically.

RESULTS

A total of 120 chest CT scans and records were enrolled in the study. Male constituted 75% of the study population. The mean age and mean duration of hospital stay were 54.70±15.56 years and 9.41±8.25 days respectively. The socio-demographic parameters are shown in Table 1.

Lesions were predominantly distributed bilaterally (98.3%) and peripherally (90.8%). In 85% of cases, all of the five lobes were involved with more common involvement of the basal segments (80%). Table 2 shows distribution characteristics of chest CT findings.

The most common CT findings were ground glass opacity with 61.7% Pure GGO and 38.3% GGO with consolidation

Table 1. Demographic profile of study population (n=120)

Parameter	Frequency (%) or mean±SD
Age (years)	54.70±15.56
Gender	
Male	90 (75)
Female	30 (25)
Smoking	10 (8.3)
Comorbidities	83 (69.2)
Hypertension	47 (39.2)
Diabetes mellitus	37 (30.8)
Cardiovascular and cerebrovascular conditions	15 (12.5)
ICU stay	75 (62.5)
Domiciliary oxygen	82 (68.3)
Mechanical ventilation	7 (5.8)
Number of hospital stay days	9.41±8.25

Table 2. Distribution characteristics of CT lesions (n=120)

Parameter	Frequency (%)
No. of lobes involved	
One	1 (0.8)
Two	1 (0.8)
Three	3 (2.5)
Four	13 (10.8)
Five	102 (85)
Lung distribution	
Unilateral	1 (0.8)
Bilateral	119 (99.2)
Transverse distribution	
Central	11 (9.2)
Peripheral	109 (90.8)
Location of lobes involved	
Left upper	117 (97.5)
Left lower	120 (100)
Right upper	112 (93.3)
Right middle	106 (88.3)
Right lower	119 (99.2)
Involved segments	
Basal	96 (80)
Non-basal	24 (20)

followed by reticulations (74.2%). Other uncommon findings mentioned in some review articles that were seen in our study were subpleural curvilinear line (30.8%), bronchial wall thickening (11.7%) and crazy paving pattern (23.3%). Atypical findings seen in our study were lymphadenopathy in 56.7% and pleural effusion in 12.5% (Table 3). Figure 1, 2, 3 and 4 show CT findings seen in the study.

The mean CT severity score was 18.35±6.87. Regarding the relationship between age, gender and CT severity of COVID-19, we found no statistical difference between age

Table 3. Reported Chest CT findings (n=120)

CT findings	Frequency (%)
Pure ground-glass opacity	74 (61.7)
Pure consolidation	0 (0)
Ground glass opacity with consolidation	46 (38.3)
Reticulations/ septal thickening	89 (74.2)
Crazy paving pattern	28 (23.3)
Halo sign	10 (8.3)
Sub-pleural curvilinear line	37 (30.8)
Bronchial thickening	14 (11.7)
Lymphadenopathy	
No	7 (5.8)
More than 1 cm	45 (37.5)
Sub-centimeter	68 (56.7)
Nodules	0 (0)
Pleural effusion	15 (12.5)
Pneumothorax	0 (0)
Cavitating lesions	0 (0)

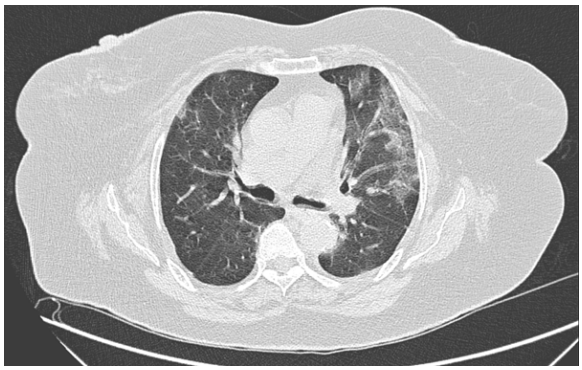

Figure 1. COVID-19 pneumonia with typical imaging features demonstrating peripheral based ground glass changes. Axial chest image (lung window) in a 68-years-old female with positive RT-PCR test results for SARS-CoV-2.

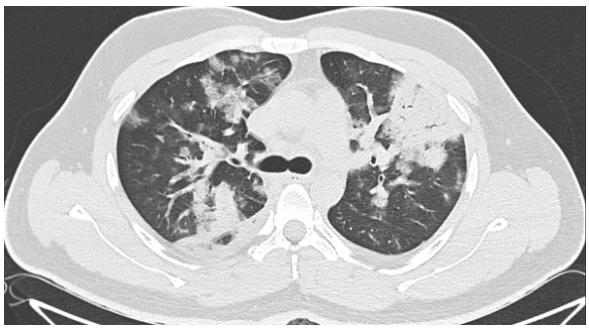

Figure 2. Mixed chest CT findings in a 72-years-old man. Axial chest image (lung window) shows consolidation in the apico-posterior segment of the left upper lobe and posterior segment of right upper lobe associated with multifocal patches of ground glass changes.

and total CT-SS (p value 0.139) and gender and total CT-SS (p value 0.085). Also, no statistical difference was observed between the segment of lungs involved (basal/non-basal) and CT-SS (p value 0.226). In the smoking cohort, smoking history and CT-SS showed no significant statistical difference (p value 0.178). Total CT-SS had a significant

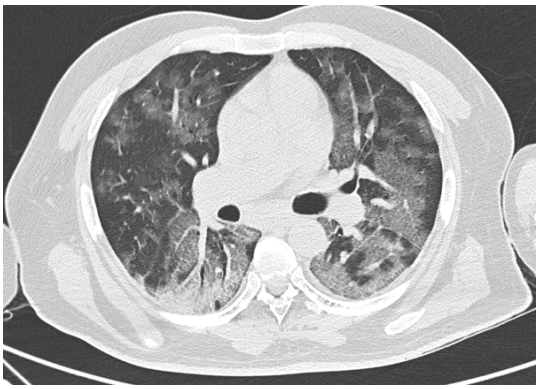

Figure 3. Crazy-paving pattern in a 46-years-old man with COVID-19. Axial HRCT chest image shows B/L ground-glass opacities with superimposed septal thickening (crazy paving appearance) on both lungs.

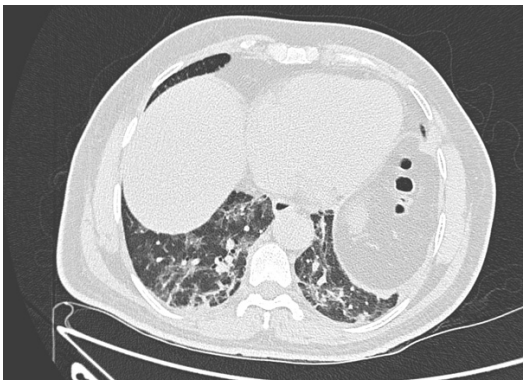

Figure 4. Axial non-enhanced chest CT image (lung window) of a 69-years-old male showing significant reticulation in both lungs mainly in the lower zones and peripheries.

correlation with the mechanical ventilation requirement (p value 0.011). The oxygen requirement with CT-SS was observed to have strong positive statistically significant correlation (p value < 0.05) (Table 4).

DISCUSSION

The seventh coronavirus, SARS-CoV-2, is highly contagious due to its pathogenicity which was first reported in Wuhan, China in the beginning of December 2019.[1] Early detection, accurately and timely, holds great significance. High resolution CT (HRCT) is considered to be an important screening tool for COVID-19 detection due to its higher sensitivity and convenience.[11] Although imaging manifestations of COVID-19 pneumonia are quite similar to common viral pneumonia, it also possesses its own unique imaging characteristics.

In this study of 120 patients with confirmed COVID-19 infection, cases were higher among males (75%) and more common in age groups below 64 years similar to a research done to assess age and gender difference among COVID-19 cases in Nepal.[12] Studies suggest that such gender distribution could be attributed to factors like disparity in behavior and possibility of protective effect of estrogen.[13] Less than 64 years of age can be explained by factors like stage of pandemic during study, common working age group who are more prone for virus transmission faster due to outdoor contacts and availability of proper healthcare system.[14] The age group of less than 64 years was more common to be affected by COVID-19 (75.8%) of which 63.74% had low-risk CT severity score. We did not find a significant relationship between age and gender with CT-severity scores.

Smoking till date is assumed to be associated with adverse disease prognosis as smoking is detrimental to the immune system making smokers more susceptible to infectious disease.[15] Our study had a limited number of smokers (8.3%) and smoking did not show statistical significance with the CT-severity score.

Table 4. Association of CT-SS score with various study variables (n=120)

Study variables		Severity (CT-SS cut-off value at 19.5)		
		Low Risk N(%)	High Risk N(%)	p- value
Age	≤ 64	58 (63.7)	33 (36.3)	.139 (Pearson)
	≥ 65	14 (48.3)	15 (51.7)	
Gender	Female	22 (73.3)	8 (26.7)	.085 (Pearson)
	Male	50 (55.6)	40 (44.4)	
Smoking	No	68 (61.8)	42 (38.2)	.196 (Fisher exact)
	Yes	4 (40)	6 (60)	
Oxygen Therapy	No	33 (86.8)	5 (13.2)	.000 (Pearson)
	Yes	39 (47.6)	43 (52.4)	
Mechanical Ventilation	No	71 (62.8)	42 (37.2)	.016 (Fisher exact)
	Yes	1 (14.3)	6 (85.7)	
Predominantly involved segment	Basal	55 (57.3)	41 (42.7)	.226 (Pearson)
	Non basal	17 (70.8)	7 (29.2)	

There was a significant relationship between the oxygen and mechanical ventilation requirements with the CT-severity scores. Oxygen requirement increases with increasing CT-severity. This can be due to direct lung damage caused by the virus that causes inflammatory changes in the alveolar wall thus limiting oxygen exchange. This further can lead to acute respiratory distress, pulmonary fibrosis and eventually cause death.[16,17]

Ground glass opacities (GGO) and consolidation are primary findings on CT scans of COVID-19 infection. GGO is considered as the most common radiological abnormality seen in up to 98% of COVID-19 cases, which was consistent with our findings.[18,19] Likewise, reticulations were noted in many COVID-19 cases up to 70.6%.[20] Crazy- paving pattern was reported in 5-36% COVID-19 patients and was observed as the sign of disease progression.[21,22] In accordance with

these studies, reticulations were seen in 74.2% and crazy-paving patterns in 23.3% in our study. Literature showed the prevalence of consolidation in the range of 2-64% in COVID-19 cases.[22,23] Unlike those, we found no pure consolidation but consolidation co-existing with GGO was observed in 38.3%.

Subpleural curvilinear line was described in about 20% of COVID-19 cases in some studies which was reported to be 30.8% in our study.[22] Halo sign and bronchial thickening were observed in very few patients only. Although pulmonary nodules were reported in 3-13% of COVID-19 CT cases and 2% incidence of pleural effusion, no significant nodules were noted in any cases of this study and pleural effusion was seen in 12.5% patients.[21] It has been suggested that pleural effusion could be due to bacterial superinfection rather than COVID-19 infection.[22,24] Apart from pleural effusion as extrapulmonary findings on CT, mediastinal lymphadenopathy has been assigned to assess the severity of COVID-19 infection and reported in 0-8% cases.[20,23] Unlikely, we found 94.2% with lymphadenopathy, the majority being sub-centimeter in size (56.7%) and only 37.5% of cases were found with significant (> 1 cm short axis diameter) lymph nodes.

Meng et al. reported GGO with 34% unilateral location involving mostly one or two lobes (38%) and 44% being peripherally distributed.[25] In contrast, we found 98.3% with bilateral distribution involving all five lobes in 85% cases. In consistent to Meng et al. peripheral distribution with mostly basal segments was observed in our study.[25] This difference could be due to the difference in study participants as our study included symptomatic patients only.

There are several limitations of this study. Assessment of severity of disease in CT reports can be subjective. This was however reduced by involving a single consultant radiologist assisted by two radiologists. Variables like age, smoking and oxygen therapy which have graded response to outcome were analysed as dichotomous variables in our study. Some patients may have received medical treatment like antimicrobial therapy, fluids and steroids that can affect CT findings which was not accounted for in this study.

CONCLUSION

CT scan plays a pivotal role in assisting clinicians for the diagnosis and assessment of severity of COVID-19 related lung changes. In our study, GGO and reticulations with bilateral involvement of all of the five lobes. CT-severity score is positively correlated with oxygen requirement in patients with COVID-19 infection and the need of mechanical ventilation, most common Chest CT findings were.

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