CT Derived Pulmonary Vascular Measurements in COVID-19 Pneumonia and Correlation with the CT Severity Score, Oxygen Requirement and ICU Admission: An Indian Perspective

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Abstract: The novel 2019 coronavirus disease (COVID-19) has become a pandemic. Many studies have reported on the computed tomography (CT) manifestations of COVID-19, however, the pulmonary vascular enlargement has not been adequately examined. The present study aimed to measure the pulmonary arteries in COVID-19 patients and correlate the vascular metrics with the lung parenchymal abnormalities and admission to intensive care units. This is a retrospective study. All RT-PCR confirmed cases of COVID-19 of age more than 18 years, managed at the institute, either at COVID-19 ward or ICU, and whose scans were performed at the department from November 2020 to June 2021 were included in the study. Two radiologists evaluated the lung findings and the vascular measurements, and the clinical information was extracted from the charts and the hospital information system. All the data was tabulated in Microsoft Excel 2019, and ANOVA was used in SPSS 23.0 for statistical analysis. A total of 158 patients were included, 119 (75.3%) being males and 39 (24.7%) females with mean age 53.45 ± 15.3 years and 50.26 ± 14.59 years respectively (overall mean age 52.66 ± 15.17 years). The CT severity score and oxygen requirement significantly correlated with the main pulmonary artery diameter ($p < .001$). The main pulmonary artery to aorta diameter ratio (P/A ratio) was significantly higher in patients requiring ICU admission (30.4% cases, mean ratio 0.88 ± 0.13), as opposed to those managed in ward (69.6% cases, mean ratio 0.83 ± 0.13). MPA diameter was significantly higher in patients requiring oxygen as compared to those who did not ($p = 0.023$). Higher P/A ratio is associated with ICU admissions in COVID-19 patients. Larger main pulmonary artery diameter is associated with increased oxygen requirement and with the CT severity score.

Keywords: RT-PCR, COVID-19, CT Chest, Viral Pneumonia

I Introduction

An outbreak of the novel corona virus SARS-Cov-2 infections started in December 2019 in Wuhan, China. The disease it causes, termed COVID-19, is a heterogeneous disease with most patients experiencing mild illness and spontaneous recoveries, but a relevant subgroup of individuals require hospitalization for pneumonia and other complications. In the initial reports from Wuhan, up to one-third of patients developed severe pneumonia with acute respiratory distress syndrome (ARDS) [1,2].

Since the outbreak, the COVID-19 pneumonia pandemic has spread rapidly and in multiple waves, with an ever-increasing utilization of computed tomography of chest (CT chest), even though it is not recommended as a screening tool. The patho-physiological lung changes in COVID-19 are easily

detectable with CT and mirror the possible evolution from viral pneumonia to acute respiratory distress syndrome (ARDS) [3,4]. Extensive lung consolidation and ARDS can alter pulmonary vasculature features, causing pulmonary hypertension, which in COVID-19 patients could also be caused by an overlap of these processes with increasingly-reported pulmonary arterial thrombosis. Early detection of pulmonary hypertension is therefore paramount to guide appropriate treatment but remains a complex diagnostic challenge, also hampered by different and complementary shortcomings of available diagnostic techniques [5].

Since the SARS-CoV-2 outbreak, CT imaging has almost immediately established itself as the primary non-invasive test for diagnosis, monitoring of COVID-19 pneumonia, and complications thereof, including deep-learning-based analysis. Early radiologic investigations consistently reported that the typical CT findings of COVID-19 pneumonia were bilateral ground-glass opacities (GGOs) and consolidation with a peripheral and posterior lung distribution [6–8].

Although vascular involvement is thought to aggravate COVID-19 morbidity and mortality, there are still unresolved issues regarding the nature and impact of cardiovascular abnormalities. Furthermore, no convincing theory helps understand the interaction between virus-induced inflammatory disorders and morphologic changes, especially those observed on CT. In addition, the severity of hypoxemia in COVID-19 patients seems to be related to more complex mechanisms than morphologic damages observed in CT [5,9]. A common imaging sign was vascular enlargement sign (VES). VES has been reported in approximately two-thirds of COVID-19 pneumonia. VES was variably defined on CT as a subjective enlargement of small pulmonary vessels compared to the contralateral lung or objectively by vessel diameter of more than 3 mm in or around the pulmonary lesions. Vessel enlargement has been noted not only in the parenchymal opacities but also in the surrounding normal lung reaching as far as the pleural surface [10].

Early radiologic investigations consistently reported that the typical computed tomography (CT) findings of COVID-19 pneumonia were bilateral ground-glass opacities (GGOs) and consolidation with a peripheral and posterior lung distribution [11–13]. The current publications on this topic are exclusively from China, and it remains unknown how COVID-19 pneumonia appears on chest radiographs and CT images of patients outside China. Therefore, this study was designed to present a preliminary report on the CT findings of COVID-19 pneumonia in India.

II Objectives

To evaluate the pulmonary vascular measurements in COVID-19 patients and correlations of the vascular metrics with CT severity, oxygen requirement and ICU admissions.

III Materials and Methods

- After approval of the Institute Ethics Committee, the authors conducted the present study, which was a retrospective analysis of prospectively maintained data.
- All adult patients (more than 18 years of age) of either sex with confirmed COVID-19 on a real time polymerase chain reaction (RT-PCR) test, who had undergone CT chest at the institute between April to December 2020, and were managed at the institute, were included.
- Patients having history of prior cardiovascular disease and poor quality or inadequate chest CT scans were excluded from the study.
- The CT examinations were done on either a 256 slice Siemens Somatom Definition Flash or Philips Ingenuity Elite 128 slice CT machine. The images stored in the institute PACS were retrieved into Siemens SyngoVia workstation and analyzed by two radiologists, one with 5 and another with 14 years' experience.

- The findings were recorded by consensus. The scans of entire lung were acquired at 0.625 mm resolution and reformatted in various planes and thickness. The lungs were evaluated for the morphology of the lesions, their locations, margins, lobe involved and bilateral involvement. Besides this, presence of bronchiectasis, pleural effusion, lymph adenopathy were also analyzed. An overall total lung severity score was reached by summing the five lobe scores (range of possible scores, 0–25), each lobe contributing maximum score of 5, as described earlier [8]. Finally, the main pulmonary artery (MPA), right pulmonary artery (RPA) and left pulmonary artery (LPA) were measured, taking the maximum diameter at the level of the MPA bifurcation, the maximum diameter of the aorta (Ao) was assessed in a single slice and MPA/Ao ratio was calculated.
- All the data was tabulated in Microsoft Excel 2019, and statistical analysis was performed using SPSS version 23.0. Continuous variables were expressed as mean ± standard deviation. Comparisons between two groups (e.g., ICU vs. ward, oxygen vs. no oxygen) were performed using an independent samples t-test. A one-way ANOVA was used for comparisons involving multiple groups (e.g., age categories). Correlations between continuous variables (e.g., MPA diameter and CT severity score) were assessed using the Pearson correlation coefficient. A p-value of less than 0.05 was considered to indicate statistical significance.

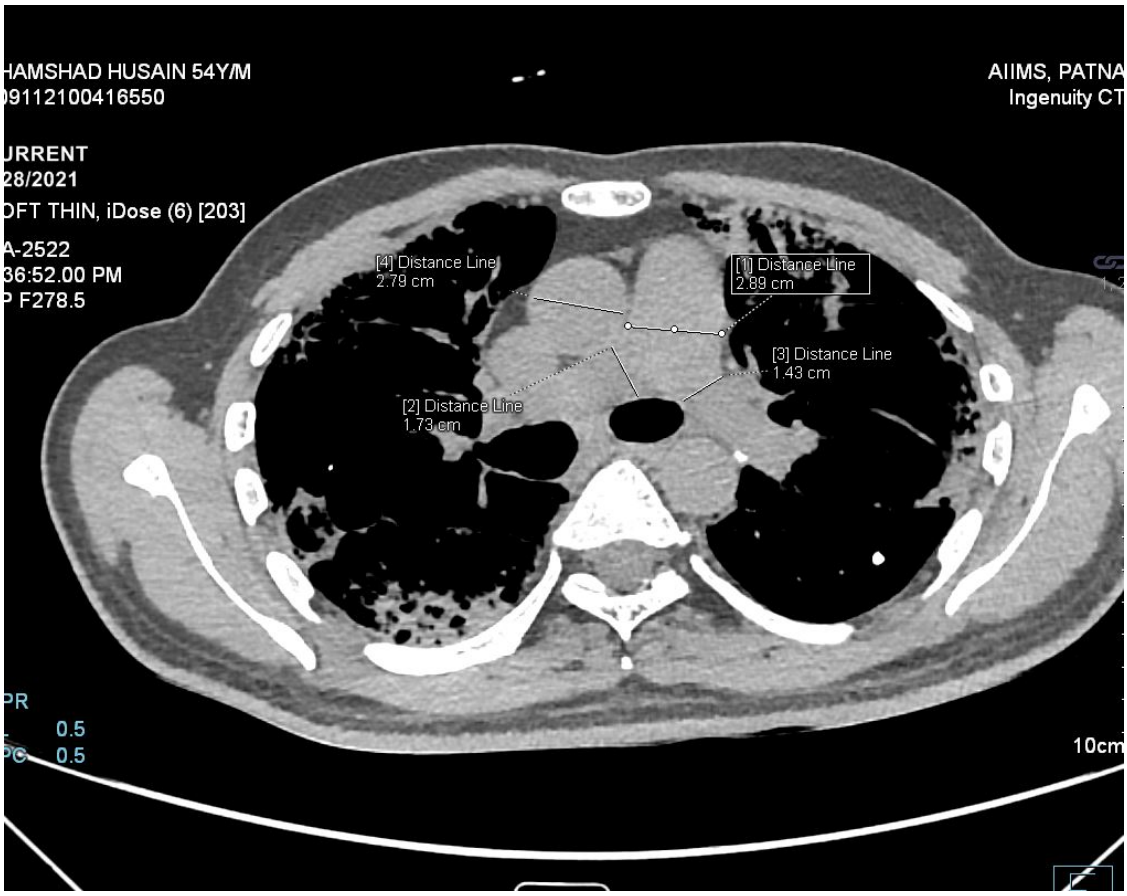

Figure 1: Vascular measurement technique. For each patient, the diameter of the main pulmonary artery (thick line) was measured at the level of its bifurcation and the diameter of right and left pulmonary arteries at the level of their origin.

IV Results

The total sample size of present study was 158, spread across all age groups, with 59.5% patients above 50 years of age, 75.3% being male and 24.7% female, (Table 1) having mean hospital stay of 18.69 days and 11.59 days respectively. Out of these, 6 patients had died during treatment and remaining 152 patients were discharged from the hospital. The baseline characteristics are detailed in Table 2 and the severity of condition is detailed in Table 3.

The predominant and characteristic finding on HRCT in COVID-19 pneumonia is ground glass opacity with some patients also having reticular opacities, bands and airway ectasia. The CT severity score takes into account the approximate volume of lung parenchyma involved using a semi-quantitative visual scoring system. The mean CT severity score was 12.36 (SD 6.27) and that of the right and left lungs measured separately were 7.27 (SD 3.85) and 5.19 (SD 2.64), with their gender-wise distribution mentioned in Table 4. Frequency of some other findings on the CT are detailed in Table 5. The chief pulmonary vascular metrics were: MPA 2.62 cm (SD 0.39 cm), RPA 1.87 cm (SD 0.36 cm), LPA 1.91 cm (SD 0.36 cm), aortic diameter 3.09 cm (SD 0.49 cm) and the P/A ratio 0.85 (SD 0.13). Their gender-wise distribution is tabulated in Table 6.

The P/A ratio was tested against ICU admission using *one way ANOVA* and was significant ($t = 2.315$, $p = 0.022$). However, it was not significant when tested against some other variables such as duration of hospital stay, gap between symptom and HRCT, duration between RT-PCR test and HRCT, CT severity score, clinical outcome, oxygen therapy, intubation and gender (Tables 7, 8). An effect of age was noted, however, with younger patients having higher P/A ratio ($F = 4.410$, $p = 0.002$), probably reflecting the larger aortic diameters with increasing age (Tables 8, 9).

Another important metric was the MPA diameter which was significantly higher in patients requiring oxygen as compared to those who did not ($t = 2.288$, $p = 0.023$), and also correlated with the CT severity score ($r = 0.261$, $p < .001$) (Tables 10, 11). However, no correlation was seen with other variables. Similar to the relation of MPA diameter with total CT severity score, RPA and LPA diameters also correlated with the individual right and left lung CT scores, respectively (Tables 10, 11).

Table 1: Demographic Characteristics

Variable	**Frequency**	**Percentage**
	Age	
<30	14	8.9
30-40	26	16.5
40-50	24	15.2
50-60	42	26.6
≥60	52	32.9
Mean Age (Males) = 53.45, SD = 15.33		
Mean Age (Females) = 50.26, SD = 14.59		
Mean Age (Overall) = 52.66, SD = 15.17		
	Sex	
Male	119	75.3
Female	39	24.7

Table 2: Baseline characteristics of 158 COVID-19 cases, detailing the distribution of symptoms, preceding lung diseases, associated co-morbidities

	Frequency	**Percentage**
Symptoms		
Fever	98	64.1
Cough	85	55.6
Breathing difficulty	54	35.3
Weakness	29	19.0
Chest pain	4	2.6
Anosmia	1	0.7
Hemoptysis	3	2.0
GI symptoms	7	4.6
Fatigue	2	1.3
Cognitive impairment	2	1.3
Lung disease		
Pulmonary emphysema	13	40.6
Bronchiectasis	8	25.0
Tuberculosis	5	15.6
Few cysts	5	15.6
Interstitial lung disease	2	6.3
Bronchial asthma	1	1.2
Co-morbidities		
Hypertension	63	39.9
Diabetes Mellitus	41	25.9
Obesity	1	0.7
Malignancy	2	1.3
Chronic renal disease	3	1.9
Anemia	2	1.3
Hypothyroidism	8	5.1
Diaphragmatic hernia	1	0.7

Table 3: Disease severity of the studied cohort of 158 COVID-19 patients

	Frequency	**Percent**
Clinical severity		
Asymptomatic	24	15.2
Mild	36	22.8
Moderate	66	41.8
Severe	32	20.3
Oxygen therapy		
Yes	103	65.2
No	55	34.8
ICU		
Yes	48	30.4
No	110	69.6
Intubation		
Yes	9	5.7
No	149	94.3

Table 4: Descriptive statistics for CT Severity score

Variable		**N**	**Mean**	**SD**
CT severity score	Male	119	12.807	6.132
	Female	39	11.000	6.597
Right lung score	Male	119	7.538	3.809
	Female	39	6.462	3.926
Left lung score	Male	119	5.294	2.585
	Female	39	4.564	2.789

Table 5: Other findings in the CT scans of 158 cases of COVID-19 pneumonia

Findings	**Number (%)**
Pulmonary nodules	10 (23.8)
Pleural effusion	10 (23.8)
Thoracic lymphadenopathy	16 (38.1)
Pericardial effusion	6 (14.3)
Cardiomegaly	4 (9.5)
Pleural metastasis	1 (2.4)
Pneumomediastinum	1 (2.4)
Fungal cavity	3 (7.1)
Bacterial cavity	2 (4.8)
Consolidation (secondary infection)	1 (2.4)
Tree in bud nodules	2 (4.8)

Table 6: Descriptive Statistics for Quantitative variables

Variable		**N**	**Mean**	**SD**
Days of Hospital stay (days)	Male	119	18.697	16.629
	Female	38	11.579	15.599
Main pulmonary artery diameter (cm)	Male	119	2.647	0.386
	Female	39	2.548	0.428
Right pulmonary artery diameter (cm)	Male	118	1.934	0.331
	Female	39	1.824	0.361
Left pulmonary artery diameter (cm)	Male	119	1.954	0.365
	Female	39	1.812	0.352
Aorta diameter	Male	118	3.159	0.442
	Female	39	2.961	0.387
Pulmonary artery to aortic diameter (P/A) ratio	Male	119	0.843	0.142
	Female	39	0.872	0.121

Table 7: Comparison of pulmonary artery to aortic diameter (P/A) ratio according to clinical variables

Variable		**N**	**Mean P/A Ratio**	**SD**	**t-stat**	**p-value**
Clinical Outcome	Discharged	152	0.852	0.139	0.971	0.333
	Death	6	0.797	0.077		
Oxygen therapy	Yes	103	0.8606	0.1460	1.384	0.169
	No	55	0.8307	0.1193		
ICU required	Yes	48	0.8881	0.1373	2.315	0.022*
	No	110	0.8337	0.1352		
Intubation	Yes	9	0.8420	0.1140	0.183	0.855
	No	149	0.8507	0.1393		
Gender	Male	119	0.8430	0.1425	1.153	0.251
	Female	39	0.8722	0.1209		

* Significant result (P<.05), NS=non-significant

Table 8: Correlations of P/A Ratio with other quantitative variables

Variable	**Pearson Correlation (p-value)**
Days of hospital stay(days)	0.115 (0.152)
CT severity score	0.133 (0.095)
Age	0.192 (0.162)
Duration between symptoms and HRCT (days)	0.030 (0.713)
Duration between RTPCR and HRCT (days)	0.070 (0.385)

** Correlation is significant at the 0.01 level (2-tailed).

Table 9: Correlations of P/A Ratio with age range

Age range in years	**N**	**Mean P/A Ratio**	**SD**	**SE**	**F-stat**	**p-value**
<30	14	0.9253	0.1458	0.0390	4.4130	0.002**
30-40	26	0.9115	0.1165	0.0228		
40-50	24	0.8436	0.1308	0.0267		
50-60	42	0.8528	0.1644	0.0254		
≥60	52	0.8003	0.1039	0.0144		

** significant value (P<.05)

Table 10: Comparison of mean MPA diameter

Variable		**N**	**Mean**	**SD**	**t-stat**	**p-value**
Gender	Male	119	2.647	0.386	1.357	0.177
	Female	39	2.548	0.428		
Oxygen therapy	Yes	103	2.675	0.374	2.288	0.023*
	No	55	2.525	0.424		
ICU	Yes	48	2.694	0.427	1.494	0.137
	No	110	2.591	0.382		
Intubation	Yes	9	2.680	0.544	0.446	0.656
	No	149	2.619	0.389		
Clinical outcome	Discharged	152	2.622	0.391	0.037	0.971
	Death	6	2.628	0.584		

* Significant result (P<.05), NS=non-significant

Table 11: Correlation of MPA with other quantitative variables

Variable	**Pearson Correlation (p-value)**
Days of hospital stay(days)	0.099 (0.218)
CT severity score	0.261** (0.001)
Age	0.114 (0.153)
Duration between symptoms and HRCT (days)	0.002 (0.984)
Duration between RTPCR and HRCT (days)	0.012 (0.879)

** Correlation is significant at the 0.01 level (2-tailed).

V Discussion

The pandemic of the novel corona virus disease (COVID-19) caused by the severe acute respiratory syndrome corona virus 2 (SARS-CoV-2), has caused a larger number of deaths in India and many other countries [14]. While the virus and consequently the disease and its epidemiology is still evolving, it is now well established that CT evaluation has played an important role in understanding the disease. It is also well known that vascular system is affected by the disease and there have been many reports of thrombotic and embolic events, both clinical and silent. This study was designed to study one such vascular parameter, i.e. the pulmonary arterial diameters and its correlation with important clinico-radiological variables, such as the CT severity score, oxygen requirement and ICU admissions, which are 'real-life' issues for the patients, physicians and the healthcare system overall. Although

there are very few studies from India reported in the current scenario of COVID-19, our study helps to generate some new data in India related to COVID-19 patients.

In this study, it has been observed that older age group affect more as compared with younger age because maximum number of patients belonged to age group more than 60 years and least number of patients belonged to age group less than 30 years. Our results also revealed more male patients as compared with female. Similar finding has been reported by Pietro Spagnolo et al. [3] from Italy as they had taken 374 patients underwent triage chest CT for suspected SARS-CoV-2 infection at Center 1 and 298 patients at Center 2. The patient's median age was 75.2 years. 62% of patients were males and 38% were female. Although very few studies were available in data base similar to present study. The Min Lang et al. [15] from USA conducted a study on COVID-19 patients as they analyzed data of 48 patients among which 52% were male and 48% were female. The mean age was 58 years in their study. This suggests that maximum number of males suffered from COVID-19 infection as compared to females; it might be due to their profession to go outside for job or other household activities.

Various symptoms were present among COVID-19 patients in our study. The presenting symptoms were cough, breathing difficulties, weakness, chest pain, anosmia, hemoptysis, fatigue and cognitive impairment. A similar study by Pietro Spagnolo et al. [3] reported presenting symptoms during COVID-19 infection in their enrolled patients were fever with dyspnea, fever with cough, in some cases only fever and only dyspnea, only cough and respiratory insufficiency.

Among 158 patients in our study, there were various lung diseases observed as shown in results. The study conducted by Sabina A. Guler et al. [16] and Min Lang et al. [15] studied COVID-19 patients and they reported severe critical illness and mild infection. Among severe infection, they reported smoking history in 34 patients, co-morbidities in 33, initial symptom in 39, pulmonary function test in 3 and arterial blood draw in 7 patients. They also reported type of co-morbidities in their study as they were interstitial lung disease, COPD, asthma, hypertension, diabetes, sleep apnoea, chronic renal failure, cancer and depression with anxiety.

The present study also evaluated CT score. The mean CT severity score was 12.36 (SD 6.27) and that of the right and left lungs measured separately were 7.27 (SD 3.85) and 5.19 (SD 2.64), with their gender-wise distribution. The similar study by Min Lang et al. [15] assessed chest CT score and they found that lobar severity score as right lower score was 2 followed by left lower score 1.9, right upper 1.6, and left upper 1.7. Average total lung severity score was 8.3. This is quite differing from our study.

The present study found that 65.2% patients were on oxygen while 34.8% patients did not require oxygen during treatment. 30.4% patients needed to be admitted in ICU while 69.6% patients were treated in normal COVID ward. Few patients (5.7%) among COVID positive were intubated also while others did not require intubation, which is quite similar data found as reported by Min Lang et al. [15] who found oxygen requirement via nasal cannula in 73% of patients and intubation was done in 27%. Their study reported 94% of patients admitted in hospital, 38% required ICU, 29% discharged from hospital and 4% deaths were reported. Our study found that more patients were discharged from hospital after being cured from COVID-19 infection as shown in result.

The present study showed various comparative parameters and found that comparison of P/A ratio according to various clinical variables. The result indicates that the P/A ratio for those who required ICU is significantly higher as compared to those who did not require ICU ($t = 2.315$, $p = 0.022$). However, it was not significant when tested against some other variables. Younger patients had higher P/A ratio ($p = 0.002$), probably reflecting the larger aortic diameters with increasing age. A similar study by Pietro Spagnolo et al. [3] found an increase both in the median P/A ratio and in the PA diameter absolute median value, that ranged from 26 to 31 mm after SARS-CoV-2 infection. Of note, all ten patients without an increased P/A ratio showed already high baseline values for both components of this parameter, suggesting that an increase in pulmonary vascular pressure may be related to the inflammatory status triggered by SARS-CoV-2 infection.

VI Conclusion

The present study concluded that P/A ratio is significantly higher in the lower age groups as compared to higher age groups enrolled COVID-19 patients. Oxygen requirement was needed in maximum patients and the time for recovery from COVID-19 was more in co-morbid patients. Higher P/A ratio is associated with ICU admissions in COVID-19 patients. Larger main pulmonary artery diameter is associated with increased oxygen requirement and with the CT severity score.

VI.a Limitations

- This study is retrospective & single-center design.
- Lack of laboratory parameters (e.g., D-dimer) to link imaging with thrombotic processes.
- Observational nature allows association, not causality.

References

[1] Huang C, Wang Y, Li X, and et al. Clinical features of patients infected with 2019 novel coronavirus in wuhan, china. *Lancet*, 395:497–506, 2020.

[2] Tsui PT, Kwok ML, Yuen H, and et al. Severe acute respiratory syndrome: clinical outcome and prognostic correlates. *Emerg Infect Dis*, 9:1064–1069, 2003.

[3] Spagnolo P, Cozzi A, Foà RA, Spinazzola A, Monfardini L, Bna C, Ali M, Schiaffino S, and Sardanelli F. Ct derived pulmonary vascular metrics and clinical outcome in covid-19 patients. *Quant Imaging Med Surg*, 10(6):1325–1333, 2020.

[4] Salehi S, Abedi A, Balakrishnan S, and Gholamrezanezhad A. Coronavirus disease 2019 (covid-19): A systematic review of imaging findings in 919 patients. *AJR Am J Roentgenol*, 2020.

[5] Salah D. Qanadli, Alexander W. Sauter, Hatem Alkadhi, Andreas Christe, and et al. Vascular abnormalities detected with chest ct in covid-19: Spectrum, association with parenchymal lesions, cardiac changes, and correlation with clinical severity (covid-cava study). *Diagnostics*, 11:606, 2021.

[6] Li Y and Xia L. Coronavirus disease 2019 (covid-19): Role of chest ct in diagnosis and management. *AJR Am J Roentgenol*, 214(6):1280–1286, 2020.

[7] Bernheim A, Mei X, Huang M, and et al. Chest ct findings in coronavirus disease-19 (covid-19): Relationship to duration of infection. *Radiology*, 295(3):200463, 2020.

[8] Zhao W, Zhong Z, Xie X, Yu Q, and Liu J. Relation between chest ct findings and clinical conditions of coronavirus disease (covid-19) pneumonia: A multicenter study. *AJR Am J Roentgenol*, 214(5):1072–1077, 2020.

[9] L. Gattinoni, S. Coppola, M. Cressoni, M. Busana, S. Rossi, and D. Chiumello. Covid-19 does not lead to a "typical" acute respiratory distress syndrome. *Am. J. Respir. Crit. Care Med.*, 201:1299–1300, 2020.

[10] Parry AH and Wani AH. Novel pulmonary vascular imaging signs in covid-19: pathophysiology, significance and management. *BJR Open*, 2(1):20210001, 2021.

[11] Soon Ho Yoon, Kyung Hee Lee, Jin Yong Kim, Young Kyung Lee, and et al. Chest radiographic and ct findings of the 2019 novel coronavirus disease (covid-19): Analysis of nine patients treated in korea. *Korean J Radiol*, 21(4):494–500, 2020.

[12] Chung M, Bernheim A, Mei X, Zhang N, Huang M, Zeng X, and et al. Ct imaging features of 2019 novel coronavirus (2019-ncov). *Radiology*, 2020. Feb 4 [Epub].

[13] Song F, Shi N, Shan F, Zhang Z, Shen J, Lu H, and et al. Emerging coronavirus 2019-ncov pneumonia. *Radiology*, 2020. Feb 6 [Epub].

[14] Liaoyi Lin, Gangze Fu, Shuangli Chen, Jiejie Tao, Andan Qian, Yunjun Yang, and Meihao Wang. Ct manifestations of coronavirus disease (covid-19) pneumonia and influenza virus pneumonia: A comparative study. *AJR*, 216:71–79, 2021.

[15] Min Lang MD, Avik Som, Denston Carey, Nicholas Reid, Dexter P. Mendoza, Efren J. Flores, Matthew D. Li, Jo-Anne O. Shepard, and Brent P. Little. Pulmonary vascular manifestations of covid-19 pneumonia. *Radiology: Cardiothoracic Imaging*, 2(3):e200277, 2020.

[16] Sabina A. Guler, Lukas Ebner, Catherine Aubry-Beigelman, and et al. Pulmonary function and radiological features 4 months after covid-19: first results from the national prospective observational swiss covid-19 lung study. *Eur Respir J*, 57:2003690, 2021.

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