Association between Main Pulmonary Artery Diameter and COVID-19 Severity- A Cross-sectional Study

AYSHA ABNA[1], ANSTON VERNON BRAGGS[2], SOUJANYA MYNALLI[3]

ABSTRACT

Introduction: Long-term consequences of the Coronavirus Disease 2019 (COVID-19) pneumonia infection, like lung vessel thrombosis and pulmonary hypertension, require prompt diagnosis and management. Hence, measurement of Main Pulmonary Artery Diameter (MPAD) in patients with moderate to severe Computed Tomography (CT)-based severity scoring helps detect the possibility of complication early. In this study, Coronavirus Disease 2019 Reporting and Data System (CO-RADS) scoring for suspected patients were done.

Aim: To measure MPAD in Reverse Transcription-Polymerase Chain Reaction (RT-PCR) COVID-19 positive (CO-RADS 6) and highly COVID-19 pneumonia suspicious patients (CO-RADS 4, 5) and then to associate with CT Severity Score (CTSS).

Materials and Methods: This cross-sectional, retrospective study was conducted in the Department of Radiodiagnosis, Father Muller Medical College, Mangalore from January 2020 to January 2022. Total of 200 patients, including 141 males and 59 females, who were highly suspicious and positive for COVID-19 pneumonia were studied. CT findings were noted, and CTSS was calculated. This was used to categorise the study sample into mild, moderate, and severe categories. MPAD was then measured for the corresponding patients. The measurement was then associated with the COVID-19 CTSS scoring using the Chi-square test, and p-value<0.05 was considered significant.

Results: Considering various parameters like age, gender, co-morbidities, and CTSS with MPAD, there was no statistically significant association between the former three parameters. Considering CTSS with MPAD, there were 72 mild, 92 moderate, and 36 severe cases. The study found a highly significant association between co-morbidities and CTSS (p-value=0.009) and a significant association between MPAD and the CTSS (p-value=0.024).

Conclusion: MPAD could be used to predict the possibility of future complications like lung vessel thrombosis and pulmonary artery hypertension in patients highly suspicious and positive for COVID-19 pneumonia.

INTRODUCTION

The COVID-19 is a worldwide health emergency that affected millions in the past few years regarding mental, physical, social, and economic status [1]. Complications of the virus are attributed not only to the invasion by the virus itself but also to the hypercoagulable state associated with severe COVID-19 pneumonia [2].

Radiological methods and laboratory investigations are the main deciding parameters for diagnosis, treatment, and prognosis [2]. Radiologically, CT is vital in diagnosing, treating, and following up on COVID-19 pneumonia patients. High-Resolution unenhanced chest CT (HRCT) is highly accurate in detecting pulmonary changes. CO-RADS score and CTSS are the two popular methods of determining the status and treatment of COVID-19 [2]. CO-RADS scoring, which includes CO-RADS 1 to 6, is a standardised reporting system for patients with suspected COVID-19. On the other hand, the CTSS assesses the degree of lung lobe involvement [2]. Accordingly, the CTSS categorises patients suspicious of the viral infection into mild, moderate, and severe categories.

Beyond the parameters describing the features of lung involvement, like interstitial pneumonia and diffuse alveolar damage, lung vessel thrombosis is one such complication that can upgrade the severity [2]. Thus, MPAD can be used as an independent parameter to risk stratify and predict the severity and mortality of COVID-19 patients. It is critical to understand the long-term consequences of the infection by this virus because early detection of pulmonary hypertension could guide the treatment of COVID-19 patients and help to modify anticoagulation therapies.

Hence, the present study was conducted to determine the association of MPAD with CTSS and to decide if it can be used as an independent parameter to predict the severity and, thus, poorer prognosis for patients with COVID-19 pneumonia.

MATERIALS AND METHODS

This cross-sectional, retrospective study was conducted in the Department of Radiodiagnosis, Father Muller Medical College, Mangalore from January 2020 to January 2022. Institutional Ethical Committee clearance (FMIEC/CCM/143/2022) was obtained. A total of 200 cases underwent HRCT imaging during the study period and fall in the category of CO-RADS 6 or CO-RADS 4 and 5 form the sample population.

Inclusion criteria: COVID-19 suspicious (CO-RADS 4 and CO-RADS 5) and COVID-19 positive (CO-RADS 6) patients were included in the study.

Exclusion criteria:

1. The COVID-19 RT-PCR-positive patients with normal HRCT and COVID-19 RT-PCR-positive patients who were not willing for an imaging study were excluded from the study.

2. Patients have been diagnosed with pneumonia from causes other than COVID-19.

3. Patients with a history of pulmonary hypertension and pulmonary thromboembolism.

[Table/Fig-1]: Measurement of Right Pulmonary Artery Diameter (RPAD) just distal to the bifurcation *RPAD. **[Table/Fig-2]:** Measurement of Left Pulmonary Artery Diameter (LPAD) just distal to the bifurcation *RPAD. **[Table/Fig-3]:** Measurement of Main Pulmonary Artery Diameter (MPAD) just proximal to the bifurcation *MPAD.

Study Procedure

Two hundred samples were studied, including COVID-19 positive and COVID-19 suspicious cases. CTSS was scored as mild (1-8), moderate (9-15), and severe (16-25) based on the percentage involvement of each lung lobe bilaterally [2]. The MPAD was then measured in the axial section mediastinum window at the level where the main pulmonary artery and its branches are well visualised. Maximum diameter was then measured for the main pulmonary artery proximal to bifurcation and its branches distal to the bifurcation [Table/Fig-1-3]. A cut-off value of >28 mm for males and >27 mm for females was considered for grading MPAD as increased or not [2]. A cut-off value of >22 mm and 20 mm was considered for grading Left Pulmonary Artery Diameter (LPAD) and Right Pulmonary Artery Diameter (RPAD), respectively [3-5]. The obtained value was then associated with the CTSS.

STATISTICAL ANALYSIS

Categorical data was represented in the form of frequency and percentage. The association between variables was then assessed with Chi-square test. Data were analysed with IBM Statistical Package for Social Sciences (SPSS) version 22.0. A p-value<0.05 was considered significant.

RESULTS

The included variables, when associated with the severity of COVID-19 (CTSS), the study found a highly significant association between co-morbidities and CTSS (p-value=0.009) and a significant association between MPAD and the CTSS (p-value=0.024) [Table/Fig-4].

Variables	Mild (n=72)	Moderate (n=92)	Severe (n=36)	p-value
Age (in years)				
<20 years	0	0	0	
20-40 years	8	11	1	0.140
41-60 years	23	42	13	
>60 years	41	39	22	
Gender				
Male	52	66	23	0.629
Female	20	26	13	
Co-morbidities				
Present	38	64	29	0.009
Absent	34	28	7	
Main Pulmonary Artery Diameter (MPAD) (mm)				
≤27 mm/≤28 mm	44	56	13	0.024
>27 mm/>28 mm	28	36	23	
Left Pulmonary Artery Diameter (LPAD) (mm)				
≤22 mm	40	50	21	0.920
>22 mm	32	42	15	
Right Pulmonary Artery Diameter (RPAD) (mm)				
≤20 mm	31	52	15	0.144
>20 mm	41	40	21	

CO-RADS				
4	1	0	0	
5	7	14	4	0.572
6	64	78	32	

[Table/Fig-4]: Baseline variables of the study population and their association with CTSS.
A p-value<0.05 was considered significant

Most patients had diabetes (n=94) and hypertension (n=82). Other co-morbidities were ischaemic heart disease (n=17), chronic obstructive pulmonary disease (n=9), asthma (n=3), chronic kidney disease (n=9), myocarditis (n=1), AKI (n=15), hypothyroidism (n=8), cerebrovascular accident (n=11) and hyperlipidemia (n=4).

Among 36 patients with CTSS in the severe category, 23 (63.8%) showed increased MPAD. This was statistically significant, with a p-value of 0.024. Among 36 patients with CTSS in the severe category, 15 patients (41%) and 21 patients (58%) showed increased LPAD and RPAD, respectively. This was statistically insignificant, with a p-value of 0.92 and 0.14, respectively [Table/Fig-4-7].

Impact of co-morbidities on MPAD: Hypertension (n=82) and diabetes mellitus (n=94) were the two most common co-morbidities in the study population. Among hypertensives and diabetics, only 42 in each co-morbidity (51% among the total hypertensives and 45% among the total diabetics) showed increased MPAD. The association was not statistically significant, (p-value=0.75 for diabetes and p-value=0.06 for hypertension). However, co-morbidities when considered in total, those patients with increased MPAD were with co-morbidities present and were statistically highly significant (p-value=0.009).
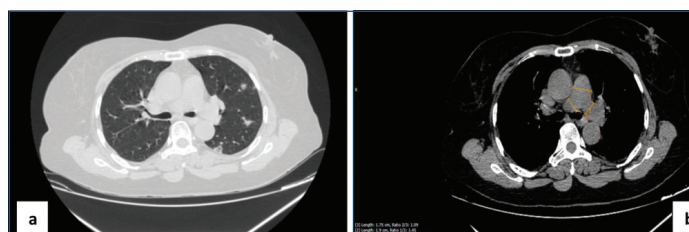
[Table/Fig-5]: Lung involvement: (a) with MPAD (27 mm), RPAD (19 mm) and LPAD (17 mm) measurement; (b) in patient with CTSS 6/25 (mild).
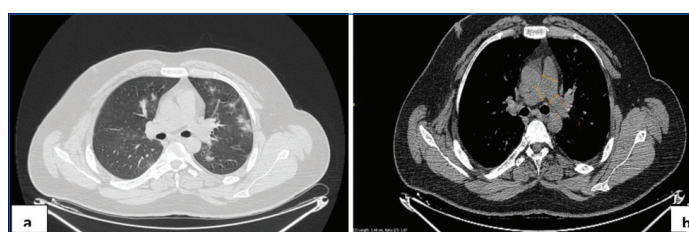
[Table/Fig-6]: Lung involvement: (a) with MPAD (23 mm), RPAD (15.9 mm) and LPAD (14.8 mm) measurement; (b) in patient with CTSS 14/25 (moderate).
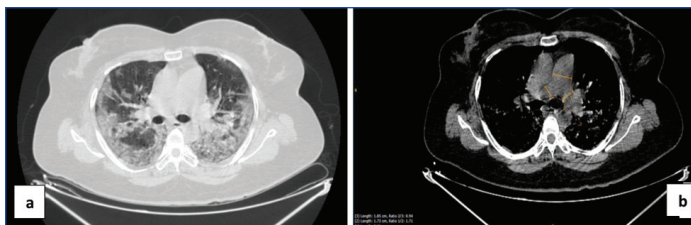
[Table/Fig-7]: Lung involvement: (a) with MPAD (29 mm), RPAD (17.3 mm) and LPAD (18.5 mm) measurement; (b) in patient with CTSS 21/25 (severe).

DISCUSSION

In the present study, the result showed a significant impact, including COVID-19 RT-PCR positive patients (CO-RADS 6) and RT-PCR negative patients with high suspicion of the infection (CO-RADS 4 and 5) of CTSS on MPAD.

Similar findings were reported in 2021 by Abhilasha et al., in their retrospective study with a limited sample size of 41 cases. When MPAD was compared with CTSS, out of 28 cases with CTSS moderate to severe, 62% had MPAD more than 29 mm with a p-value <0.001. The study concluded that MPAD could be used as an independent parameter to risk stratify and predict severity and mortality in COVID-19 patients [2].

One of the main drawbacks of the present study was the inclusion of patients with co-morbidities, which showed a highly significant association with MPAD. This drawback was overcome by Abhilasha et al., in their study by excluding such cases, but our study with a much larger sample size supported their observation of the association of CTSS with MPAD [2]. Another study by Suzuki YJ et al., showed that 70% of cases infected with COVID-19 showed moderate-severe enlargement of MPAD (p-value of <0.005) and concluded that Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) could increase the susceptibility of infected individuals to develop pulmonary arterial hypertension in the future [6].

A similar observation was also seen in a study conducted by Yildiz M et al., including 101 patients with COVID-19 pneumonia, subdivided the study sample into group-1, group-2, and group-3 based on the severity of parenchymal involvement. The MPAD was 26.11±3.72, 26.62±2.95, and 28.59±3.63, respectively, with a p-value of 0.027 [7]. In another study by Erdoğan M et al., which included 255 hospitalised severe COVID-19 patients, they showed that MPAD ≥29.15 mm can be used as an independent predictor of in-hospital mortality with a p-value <0.001 [8].

Spagnolo P et al., in their study to assess pulmonary vascular metrics with pneumonia extent, including 45 RT-PCR positive patients, found significantly higher pulmonary artery diameter in patients with unfavourable outcomes, p-value=0.001 [9].

In their retrospective study, Rani S et al., which included 90 COVID-19-infected patients, the majority being in the mild category, found a significant association between the severity and MPAD as well as LPAD with a p-value <0.001 [10]. However, the present study, with the majority being in the moderate category and a much larger sample size, did not find a significant association of LPAD with CTSS (p-value of 0.92).

In a retrospective study by Riachy MA et al., which included 465 patients with baseline CT chest, a significant correlation was found between baseline pulmonary artery diameter with hospital length of stay and discharge status of the patients with a p-value of 0.005 and 0.023 respectively. Hence, the study concluded that baseline pulmonary artery diameter is useful as a prognostic parameter [11].

Similarly, Aliev AF et al., in a single-centered cross-sectional study, including 511 patients with COVID-19 who underwent CT chest, obtained a significant correlation of dilated pulmonary artery with the degree of lung damage, (p-value of <0.001) [12].

Furthermore, Selcuk A et al., in their retrospective study including 209 COVID-19 patients with previous chest CT, also showed that patients with increased pulmonary artery diameter had significant risks for ICU admission, intubation and thus the mortality (p-value<0.01) [13].

All these studies showing similar results with significant p-value prove that MPAD measurement can potentially impact deciding patient treatment and risk stratification as well. Thus, it helps in the early detection of the possibility of pulmonary artery hypertension to start prompt treatment.

Limitation(s)

The measurement of MPAD and CTSS were subjective. Hence, the measurements can show inter-observer variation. This was a retrospective study and no follow-up, so the outcome is unknown. Inclusion of patients with co-morbidities also contributed as limitation of the study.

CONCLUSION(S)

A statistically significant association was found between CTSS and increased MPAD. MPAD could be used to predict the possibility of future complications like lung vessel thrombosis and pulmonary artery hypertension in patients highly suspicious and positive for COVID-19 pneumonia. Hence, measuring MPAD may help in prompt treatment for a future complication of the infection.

REFERENCES

[1] Esposito A, Palmisano A, Toselli M, Vignale D, Cereda A, Rancoita PMV, et al. Chest CT-derived pulmonary artery enlargement at the admission predicts overall survival in COVID-19 patients: insight from 1461 consecutive patients in Italy. Eur Radiol. 2021;31(6):4031-41.

[2] Abhilasha, Sharanayya, Bharathi M, Gouda HS. Role of HRCT pulmonary artery diameter measurement in assessment of severity and prognosis of COVID-19 patients: Asian J Med Radiol Res. 2021;9(1):09-13.

[3] Hacking C. Pulmonary trunk | Radiology Reference Article | Radiopaedia.org [Internet]. Radiopaedia. [cited 2023 Jan 9]. Available from: https://radiopaedia.org/articles/pulmonary-trunk

[4] Hacking C. Left pulmonary artery | Radiology Reference Article | Radiopaedia.org [Internet]. Radiopaedia. [cited 2023 Jan 9]. Available from: https://radiopaedia.org/articles/left-pulmonary-artery

[5] Hacking C. Right pulmonary artery | Radiology Reference Article | Radiopaedia.org [Internet].Radiopaedia. [cited 2023 Jan 9]. Available from: https://radiopaedia.org/articles/right-pulmonary-artery

[6] Suzuki YJ, Nikolaienko SI, Shults NV, Gychka SG. COVID-19 patients may become predisposed to pulmonary arterial hypertension. Med Hypotheses. 2021;147:110483.

[7] Yildiz M, Yadigar S, Yildiz BŞ, Aladag NB, Keskin O, Ozer RS, et al. Evaluation of the relationship between COVID-19 pneumonia severity and pulmonary artery diameter measurement. Herz. 2021;46(1):56-62.

[8] Erdoğan M, Öztürk S, Erdöl MA, Kasapkara A, Beşler MS, Kayaaslan B, et al. Prognostic utility of pulmonary artery and ascending aorta diameters derived from computed tomography in COVID-19 patients. Echocardiogr Mt Kisco N. 2021;38(9):1543-51.

[9] Spagnolo P, Cozzi A, Foà RA, Spinazzola A, Monfardini L, Bnà C, et al. CT-derived pulmonary vascular metrics and clinical outcome in COVID-19 patients. Quant Imaging Med Surg. 2020;10(6):1325-33.

[10] Rani S, Sah NK, Kumar R, Boora N. Assessment of the correlation between covid-19 pneumonia severity and pulmonary artery diameter measurement with computed tomography scan. Asian J Pharm Clin Res. 2022;15(11):73-77.

[11] Riachy MA, Ismail A, Awali M, Farah F, Haddad SF, Kerbage A, et al. Pulmonary artery enlargement: an independent risk factor for mortality in patients hospitalised with COVID-19. Mayo Clin Proc Innov Qual Outcomes. 2022;6(5):399-408.

[12] Aliev AF, Kudryavtsev ND, Petraikin AV, Artyukova ZR, Shkoda AS, Morozov SP. Changing of pulmonary artery diameter in accordance with severity of COVID-19 (assessment based on non-contrast computer tomography). Digit Diagn. 2021;2(3):249-60.

[13] Selcuk A, Ilgin C, Karakurt S. Association of the changes in pulmonary artery diameters with clinical outcomes in hospitalised patients with COVID-19 infection: A cross-sectional study. Marmara Med J. 2022;35(3):355-61.

PARTICULARS OF CONTRIBUTORS:
1. Junior Resident, Department of Radiodiagnosis, Father Muller Medical College and Research Institute, Mangalore, Karnataka, India.
2. Assistant Professor, Department of Radiodiagnosis, Father Muller Medical College and Research Institute, Mangalore, Karnataka, India.
3. Senior Resident, Department of Radiodiagnosis, Tata Memorial Hospital, Mumbai, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Aysha Abna,
Junior Resident, Department of Radiodiagnosis, Father Muller Medical College and Research Institute, Mangalore, Karnataka, India.
E-mail: abna.ayesha246@gmail.com

AUTHOR DECLARATION:
• Financial or Other Competing Interests: None
• Was Ethics Committee Approval obtained for this study?   Yes
• Was informed consent obtained from the subjects involved in the study?   No
• For any images presented appropriate consent has been obtained from the subjects.   NA

PLAGIARISM CHECKING METHODS: [Jain H et al.]
• Plagiarism X-checker: Jul 29, 2022
• Manual Googling: Jan 24, 2023
• iThenticate Software: Jan 28, 2023 (7%)

ETYMOLOGY: Author Origin