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CT-Determined Maximum Pulmonary Artery to Ascending Aorta Diameter Ratio in Nonsevere COVID-19 Patients

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Unenhanced chest computed tomography (CT) has been frequently suggested for diagnosing and assessing the severity of coronavirus disease 2019 (COVID-19) patients (1,2). Eslami et al. reported that CT-measured cardiac indices may be a predictor of mortality in hospitalized COVID-19 patients (3). They also observed that extensive lung involvement was positively associated with elevated cardiothoracic ratio and increased maximum pulmonary artery (PA) diameter in relation to the ascending aorta (Ao) (PA:Ao ratio) (3). PA:Ao ratio represents a noninvasive tool to detect pulmonary hypertension (PH). COVID-19 commonly presents with a hypercoagulable state and is associated with a high incidence of pulmonary thrombotic complications (4), which may aggravate the right ventricle (RV) afterload, leading to RV dysfunction. In effect, reduced RV systolic function is prevalent and associated with all-cause mortality among patients hospitalized with COVID-19 pneumonia. D'Andrea et al. found increased mean pulmonary artery pressure values and RV dysfunction among patients with COVID-19 pneumonia, which was ultimately associated with a higher risk of in-hospital mortality (5). Likewise, Li et al. reported that the RV fractional area change and the RV longitudinal strain are powerful predictors of mortality in COVID-19 patients (6).

We performed a retrospective, multicenter, cross-sectional study between March and July 2020. Patients were eligible for inclusion if: (1) an emergent surgical procedure was required; (2) a standard-of-care chest CT was performed; (3) SARS-CoV-2 infection was confirmed by reverse transcriptase-polymerase chain reaction (RT-PCR); (4) symptomatic COVID-19 with mild severity at the time of imaging; (5) no medical history of cardiac or pulmonary disease. The study was performed under a waiver of informed consent and in accordance with the Declaration of Helsinki. All CT examinations were performed without contrast two radiology centers; center 1 employed a 64 × 2-slices CT scanner (Aquilion CXL, Toshiba/Canon Medical Systems, Ōtawara, Japan) whereas center 2 employed a 16-slices CT scanner (LightSpeed RT 16, General Electric Healthcare, Chalfont St. Giles, UK). Two radiologists with over 10 years of experience independently evaluated the images. PA diameter was measured its bifurcation level with Ao measured in the same CT image slice. The PA:Ao ratio was calculated with a value ≥ 1 indicative of PA dilatation. The calculated ratio was compared to standard reference ranges from the Framingham Heart Study adjusted for age and sex (7). The extent of COVID-19 pulmonary involvement was assessed using a semi-quantitative CT severity score (8).

Among 120 patients meeting eligibility criteria, 45 were excluded, leaving a total sample of 75 patients with nonsevere laboratory-confirmed COVID-19 and without preexisting cardiopulmonary disease. The median age was 50 years (IQR: 42−60), with males accounting for 57.3% of patients. All patients demonstrated radiologic evidence of COVID-19 pneumonia. The results are shown in Table 1. The median PA:Ao ratio was 0.9 (IQR: 0.8−1.0). Exactly one-third of patients (25/75; 33.3%) had a PA:Ao ratio ≥ 1, which indicates PA dilatation, while 54.7% were above the 90th percentile for normative reference ranges. PA:Ao was not correlated with CT severity score ($p = 0.469$) or age ($p = 0.216$), nor was associated with location ($p = 0.878$), distribution ($p = 0.091$), or laterality ($p = 0.743$) of pulmonary infiltrates.

We found a PA:Ao ratio ≥ 1 among one-third of our sample of mild COVID-19 patients, with over half of them having a ratio $>$90th percentile for normative values (7). We did not find any significant correlation between the PA:Ao ratio and CT severity of pneumonia. Patients with COVID-19 are reported to present with silent hypoxemia despite minor parenchymal involvement. Our results suggest a pulmonary vascular involvement in COVID-19 patients, even among those with relatively mild disease, which is not exclusively acute PE nor is associated with the extent of CT lung involvement. The dilation in pulmonary arteries of COVID-19 patients may be explained by increased pulmonary artery pressure due to acute PE or peripheral, small pulmonary emboli. This may explain low gas exchange out of proportion to the extent of parenchymal disease and not explained by visible thrombus.

Since pulmonary hypertension is likely due to microvascular thrombi, identifying patients who may benefit from enhanced screening (cardiac echocardiography) and early and more aggressive anticoagulation is crucial. Determining PA:Ao ratio by unenhanced chest CT may anticipate the presence of underlying vascular thrombosis associated with poor outcomes, especially when is not associated with extensive parenchymal lung involvement.

TABLE 1. Pulmonary Artery Metrics, CT Features, and Relationship Between PA:Ao Ratio and COVID-19 CT Severity Score

Pulmonary artery metrics	
PA	28 (25−31) mm
Median (IQR)	
Ao	
Median (IQR)	31 (28−35) mm
PA:Ao ratio	0.9 (0.8−1.0)
Median (IQR)	
CT features	
Distribution of infiltrates	
Peripheral, n (%)	47 (62.7%)
Peripheral and Central, n (%)	28 (37.3%)
Laterality of infiltrates	
Unilateral, n (%)	5 (6.6%)
Bilateral, n (%)	70 (93.3%)
Lung area of infiltrates	2 (2.7%)
Anterior only, n (%)	12 (16.0%)
Posterior only, n (%)	61 (81.3%)
Anterior and posterior, *n* (%)	
Disease pattern	
Ground-glass opacities, n (%)	74 (98.7%)
Crazy-paving pattern, n (%)	47 (62.7%)
Peripheral consolidation, n (%)	13 (17.3%)

COVID-19 CT severity score by PA:Ao ratio		
CT severity score by lobe	(PA:Ao) ratio	
	<1 (*n* = 50) Median (IQR)	1 or more (*n* = 25) Median (IQR)
Right upper lobe	1 (0−2)	1 (0−2)
Middle lobe	1 (1−2)	1 (1−2)
Right lower lobe	2 (1−3)	1 (1−4)
Left upper lobe	1 (1−2)	1 (0−2)
Left lower lobe	2 (1−3)	1 (1−4)
Total Score*	7 (3−12)	5 (4−13)

Ao, maximum aorta diameter; PA, maximum pulmonary artery diameter.

Each of the five lung lobes was assessed on a scale of 0 to 5, with 0 indicating no involvement; 1, less than 5% involvement; 2, 5%−25% involvement; 3, 26%−49% involvement; 4, 50%−75% involvement; and 5, more than 75% involvement. The individual lobar scores were then summed to calculate the total CT score, which ranges from 0 (no involvement) to 25 (maximum involvement).

* Mann−Whitney *U* test, *p*-value = 0.687.

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