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Pulmonary Artery To Ascending Aorta Ratio On Pulmonary Computerized Tomography In Patients With COVID-19 Infection

Haider Najim Al-Tameemi[(1)] and Assad Hussien Sachit[(2)]

[(1)]FIBMS-radiodiagnosis, Department of Radiology, Middle Euphrates Neuroscience Center, Faculty of Medicine, University of Kufa, Al-Najaf, Iraq.
[(1)]FIMS-radiodiagnosis, Department of Radiology, Al-Sader Medical City, Al-Najaf Health Directorate, Al-Najaf, Iraq.

Corresponding Author Email: haidern.altameemi@uokufa.edu.iq

Abstract

Background. Majority of patients infected with coronavirus disease 2019 (COVID-19) present with an acute respiratory illness of varying severity. Chest computerized tomography (CT) is one of the important steps in the diagnostic work-up of pulmonary involvement. Cardiovascular complications including pulmonary arterial (PA) abnormalities have been recently emphasized upon. **This study aims** to evaluate the relationship between severity of pulmonary infection and pulmonary artery/aorta (PA/AA) ratio on chest CT scan. **Material and Methods.** This cross section study was conducted on 74 patients with confirmed diagnosis of COVID-19 who underwent chest CT scans.. Radiologists assessed every CT examination and graded the extent of pulmonary involvement and severity score obtained. The diameters of PA and aorta were measured and PA/AA ratio was then calculated. **Results.** Among 74 patients, 28 patients have abnormal PA/AA ration (>1) . Twenty four patients (32.2%) were classified as mild, 39 (52.7%) as moderate and 11 (14.8%) as severe, with statistically significant difference regarding presence of abnormal PA/AA ratio (P> 0.05) specially in patients with severe pulmonary involvement. There was no significant difference regarding gender and age groups. There was no statistically significant relationship between PA/AA ratio and pattern of pulmonary radiological findings**.**

Conclusion. Covid-19 patients with severe pulmonary involvement (higher severity score) tend to have abnormal PA/AA ratio. PA /A ratio could be used as an additional prognostic radiological marker in assessment of Covid-19 infection**.**

Keywords: Pulmonary Artery, Ascending Aorta, Computerized Tomography, Covid-19 Infection.

INTRODUCTION

Coronavirus disease 2019 (COVID-19), the pandemic caused by the novel coronavirus known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first identified in Wuhan, China in December 2019. The pandemic has significant impact on health and economic status [(1)]. Patients with COVID-19 present with an acute respiratory illness of

varying severity [2]. Chest computed tomography (CT) scan is commonly used for diagnosis and severity assessment of COVID-19 pneumonia [3] and recommend for subjects with moderate to severe cases or in those with unexplained deterioration of respiratory status [4]. Radiological findings pulmonary changes in patients affected by COVID-19 are readily detectable with CT and reflect the pathophysiological changes [5, 6]. Usually bilateral and asymmetrical, these findings include ground-glass opacities (GGO), consolidation, crazy-paving pattern, and less frequently nodules, bronchial wall thickening, vascular enlargement, bronchiectasis, septal thickening, pleural effusion, lymphadenopathy and subpleural bands [7, 8]. Severity of pneumonia has been linked to an increased risk of death and extensive changes on CT were found to be associated with a worse prognosis and higher mortality [9]. The ratio between the diameter of the pulmonary artery (PA) and that of the ascending aorta (AA) measured using chest CT scan, to assess pulmonary hypertension correlates with results from invasive measures of PA pressure [10, 11]. PA/AA ratio >1 was suggested to be a reliable indicator of pulmonary hypertension [12]. In patients with chronic obstructive airway disease (COPD), PA/AA >1 is related to an increased rate of severe exacerbations and considered as an independent predictor of morbidity and mortality [13, 14, 15]. Because PA/AA ratio can be easily assessed on unenhanced CT scans, we hypothesized that this ratio can represent a useful prognostic index in patients with COVID-19 infection. We therefore performed this cross-sectional study, aiming to measure PA/AA on chest CT scans performed during acute infection and assess its correlation with severity of radiological pulmonary involvement.

MATERIAL AND METHODS

This hospital-based cross-sectional study was conducted on 74 patients with confirmed diagnosis of COVID-19 between February 2020 and October 10, 2020. Inclusion criteria were adult (> 18 years) patients having positive diagnosis of COVID-19 by real-time reverse transcriptase polymerase chain reaction (RT-PCR) assay, who underwent chest CT imaging. Patients with history of any pulmonary or cardiovascular disease and suboptimal CT image quality were excluded. Demographic data, past medical history, laboratory tests and presenting signs and symptoms were obtained from patients. Because of non-interventional nature of the study, oral consent was taken from every patient to include their data in the study and the study was approved by the Institutional Review Board. Chest CT examination: All patients underwent non-enhanced chest CT using the same 64-slice CT scanner (Siemens Healthineers, Erlangen, Germany) in supine position during end-inspiration. CT protocol was utilized with the following parameters: Gantry rotation time of 0.5 seconds, 0.625 mm, pitch of 1.4, table speed of 45.2 mm/rotation, 30 mAs,120 kVp, and a 300X300 matrix. A 5 mm slice thickness and 1mm reconstruction interval were used for sagittal and coronal image reconstruction. Two expert radiologists (first with 18 years and the second with 10 years of experience in general and thoracic radiology) independently evaluated the CT images. Both observes were blinded to the laboratory data, clinical features and diagnosis. They reached a final decision by consensus and when disagreement occurs, a third radiologist was consulted for his opinion. All CT images were viewed in multiplanar sections, including axial, sagittal and coronal planes, and evaluated as follow:

1- Pattern of lung involvement was classified as GGO, consolidation, crazy paving or mixed. Imaging findings like pleural effusion, reversed halo sign, bronchial wall thickening and lymphadenopathy were also documented.

2-The severity of lung involvement on chest CT was assessed in two steps: firstly, each lobe

was assigned a score between 1 and 5 according to the percentage of lobe involvement [16]; where 1 is given when <5% of the lobe is involved, 2 when 5–25%, 3 when 25–50%, 4 when 50–75% and maximum of 5 is given when > 75% of lobe is affected. By summation of score of the 5 lobes of both lungs, we obtain a total score of 25 (for example 5/25, 15/25, 22/25,,,etc). Therefore each patient will have a score between (0), denoting no lung involvement, to (25), denoting the maximum lung affection. Secondly, according to the total score, cases are classified into three categories (Fig. 1) into: mild (score 0-8) ; moderate (score 9-15) and severe (score >15).

3- PA/AA ratio was calculated as the ratio of the PA diameter measured at the level of the PA bifurcation to the ascending aorta diameter measured using the same CT section on mediastinal windows (Fig. 2). Abnormal PA/AA ratio was defined as PA/AA>1.

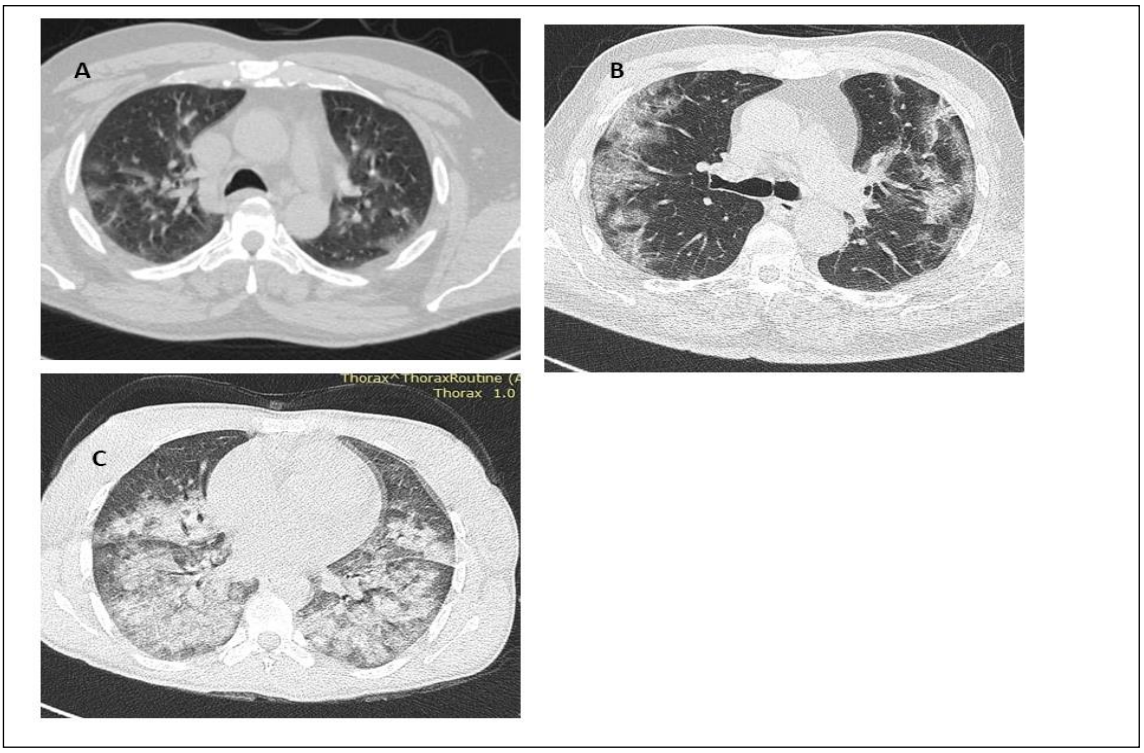

Figure No.1: Non –enhanced chest CT scans of different patients with acute COVID-19 infection, showing different severity scores, from mild (A), moderate (B) to severe (C).

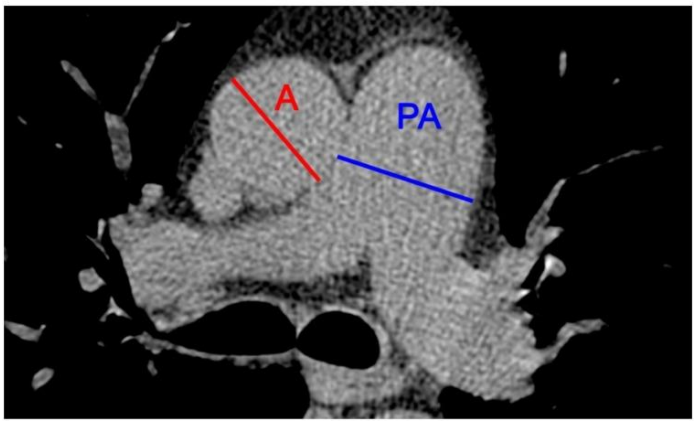

Figure NO. 2. Measurement of the pulmonary artery (PA) and aorta (A) at the PA bifurcation

Statistical Analysis

Normal continuous variables are represented as mean and SD. Categorical data are reported as frequency (percentage). Independent t test and Mann-Whitney U test were used for comparison. Chi-square test was used for comparison of categorical variables. A P-value <0.05 was considered significant. statistically

RESULTS

A total of 74 covid-19 infected patients (49 male and 25 female) were included in this study with mean age of 47 +_ 4.4, and range 18-70 years, Abnormal PA/AA ratio was seen more in males than females (16 versus 12) but no statistically significant difference was found (P>0.05) (Tab. 1). Similarly, there was no statistically significant difference (P>0.05) regarding normal versus abnormal PA/AA ration according to age of studied population (Tab. 2). The most common patterns of disease included GGO, observed in all 74 patients (100%), followed by only GGO (44.5%), GGO with crazy-paving pattern (3%) and GGO with parenchymal consolidations (4.1 %) while those showing all findings were 14 cases (18.2%). However, no statistically significant association was found with abnormal PA/AA ratio findings (p value =0.171), as shown in Tab, 3. Regarding severity score on CT scan 24 cases (32.2%) were classified as mild, 39 as moderate (52.7%), and 11 patients (14.8%) as severe (Fig. 3), with statistically significant difference in presence of abnormal PA/AA ratio (P value = 0.018), as shown in table 4) .

Table No. 1: Distribution of patients with normal and abnormal PA/AA ratios according to gender.

PA/AA Ratio	Gender	Number	Percentage	P value
Normal	Male	33	57.1%	0.070
	Female	13	42.9%	
Abnormal	Male	16	71.7%	
	Female	12	28.3%	

Table No2: Distribution of patients with normal and abnormal PA/AA ratio according to age.

PA/AA ratio	Number	Mean age (year)	S.D	P value
Normal	46	47.6087	13.815	0.804
Abnormal	28	46.7857	13.736	

Table No.3: Relationship between PA/AA ratio and type of pulmonary involvement.

Radiological finding	PA/AA Ratio		Total	P value
	Normal	Abnormal		
GGO* only	21 (63,6%)	12 (36.4%)	33	0.171
GGO + Crazy Paving	18 (75%)	6 (25%)	24	
GGO+ Consolidation	2 (66.7%)	1 (33.3%)	3	
All findings	5 (35.8%)	9 (64.2%)	14	

*GGO= ground glass opacity

Table No.4: Relationship of PA/AA ratio with severity scoring of pulmonary involvement.

Severity	PA/AA Ratio		Total	P value
	Normal	Abnormal		
Mild	17 (70.8%)	7 (29.2%)	24	0.018
Moderate	25 (64.1%)	14 (35.9%)	39	
Severe	4 (36.4%)	7 (63.6%)	11	
Total	46	28	74	

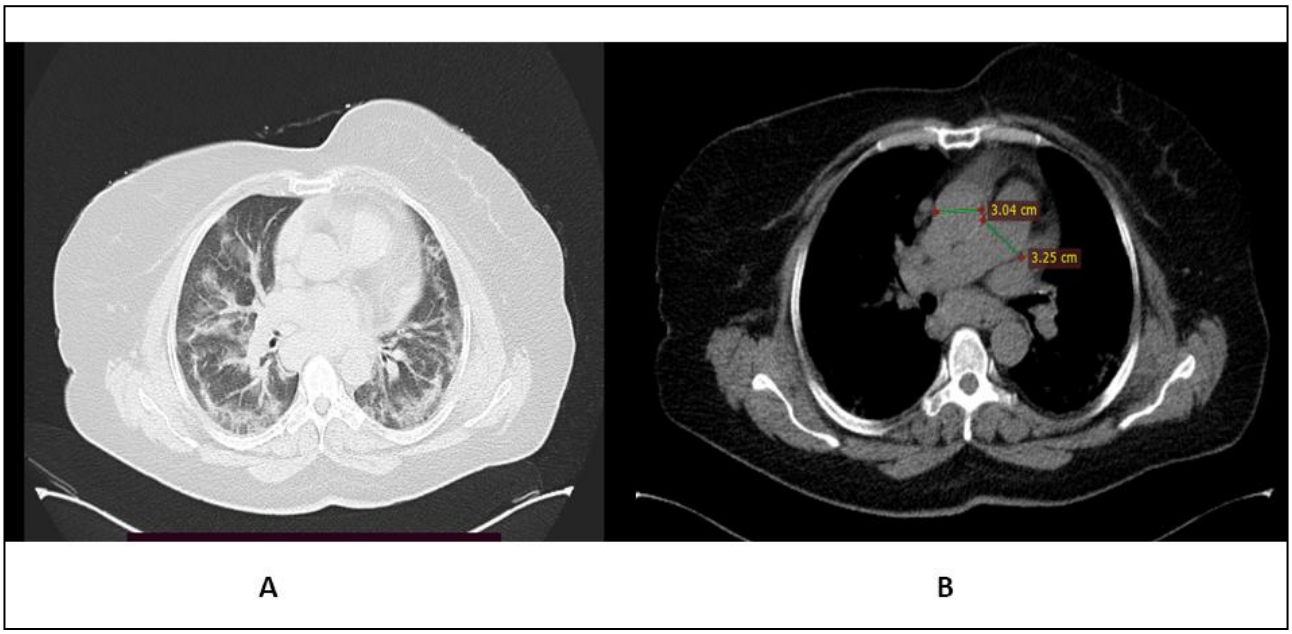

Figure No 3: Selected chest axial CT images of a 63-year old femal with COVID-19 infection. Lung window image (A) shows diffuse bilateral GGO paranchymal changes with estimated severity score of 18/25 (severe) and the PA/AA ratio assessed on the mediastinal widow image (B) is abnormal (>1).

DISCUSSION

It has been suggested that pathological events other than alveolar damage might be responsible for the acute hypoxemia related to COVID-19 pneumonia.[17], including microvascular thrombi [18, 19] and other cardiovascular abnormalties system which have been implicated in severe cases [20]. Measurements of the PA/AA ratio constitutes a non-invasive tool for the detection of pulmonary hypertension using CT scan, [21, 22]. In our study, 28 out of 74 patients (47.9%) had abnormal PA/AA ratio (>1) with statistically significant difference when correlated with severity of pulmonary involvement as assessed by chest CT score. This is mainly related to pulmonary complications presumed to result from viral-induced inflammation and the consequent cytokine storm [23], in addition to the abnormal pulmonary hemodynamics secondary to severe consolidation with inflammatory and vascular changes, resulting in vascular enlargement [24, 25, 26]. The result of current study are consistent with Hu Q et al study which attributed the elevation in PA pressure to the inflammation triggered by SARS-CoV-2 infection [27] with autoimmune endothelial disruption, seen to other coronaviruses [28], and thrombosis, all reported in COVID-19 patients with the worse prognosis [29, 30, 31]. High PA:A ratio could reflect the resting pulmonary hypertension, but other factors like left heart failure and may also

contribute, providing another explanation of high PA/AA ratio [20, 32] as pulmonary vascular consequences of myocardial damage caused by COVID-19 infection have been documented [20, 22, 34]. This radiological evidence of abnormal PA/AA ratio provides an additional method in the assessment of the severity patients with COVID-19 [35]. Early detection of abnormal PA/AA ratio at admission could guide management of COVID-19 patients, including use of anticoagulation as therapeutic rather than prophylactic option [36 ,37] aiming AT minimizing mortality, particularly in cases with of severe involvement.[27] .The representative chest CT findings of patients with COVID-19 are peripheral and/or subpleural GGO with or without crazy paving or consolidation for common patients [38, 8]. However, the current study did not find a statistically significant difference among different pulmonary patterns when correlated with abnormal PA/AA ratio. This could indicate that the effects on PA and possible pulmonary hypertension is related to the extent and severity rather than type of pulmonary involvement as. Therefore, radiologists should pay more attention to the severity score estimation and carefully evaluate the extent of findings through lungs and no to confine their assessment on pure diagnosis of the disease. This study has some limitations. It was a cross-sectional study with limited number of patients, Thus some conclusions are preliminary. More powerful studies with pooled data from multiple centers are needed in future subsequent studies. Intravenous contrast was not given and angiographic examinations were not performed to properly evaluate the pulmonary circulation especially for associated PA thrombosis.

CONCLUSION

Abnormal PA/AA ratio (> 1) was associated with the higher severity score of pulmonary involvement. No significant gender or age difference was present regarding abnormal PA/AA ratio. Overall findings of the current study suggest considering chest CT as a fast and reliable method to assess pulmonary circulation in patients with COVID-19 pneumonia. The study recommends measuring PA/AA ratio in patients with acute covid-19 infection on CT chest scan to identify high-risk patients so that appropriate therapeutic measures be taken in advance. Further studies with larger sample to assess evolution of PA diameter and correlation with outcome are also suggested.

REFERENCES

1- Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y. et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. The lancet. 2020 Feb 15;395(10223):497-506.

2- Chauhan S. Comprehensive review of coronavirus disease 2019 (COVID-19). Biomed J. 2020 Aug;43(4):334-340.

3- Hui DS, Azhar EI, Madani TA, Ntoumi F, Kock R, Dar O, et al. The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health—The latest 2019 novel coronavirus outbreak in Wuhan, China. International journal of infectious diseases. 2020 Feb 1;91:264-6.

4- Homayounieh F, Ebrahimian S, Babaei R, Karimi Mobin H, Zhang E, Bizzo BC et al. CT Radiomics, Radiologists and Clinical Information in Predicting Outcome of Patients with COVID-19 Pneumonia. Radiology: Cardiothoracic Imaging. 2020 Jul 23;2(4):

5- Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical characteristics of coronavirus disease 2019 in China. New England journal of medicine. 2020 Apr 30;382(18):1708-20.

6- World Health Organization. Home care for patients with suspected novel coronavirus (COVID-19) infection presenting with mild symptoms, and

management of their contacts: interim guidance, 04 February 2020. World Health Organization; 2020.

7- Kong W, Agarwal PP. Chest imaging appearance of COVID-19 infection. Radiology: Cardiothoracic Imaging. 2020 Feb 13;2(1):

8- Sultan, O.M., Al-Tameemi, H., Alghazali, D.M., Abed M., Abu Ghniem MN., Hawiji DA. et al. Pulmonary ct manifestations of COVID-19: changes within 2 weeks duration from presentation. Egypt J Radiol Nucl Med 2020; 51, 105

9- Kandathil A, Chamarthy M. Pulmonary vascular anatomy & anatomical variants. Cardiovascular diagnosis and therapy. 2018 Jun;8(3):201.

10- Devaraj A, Wells AU, Meister MG, Corte TJ, Wort SJ, Hansell DM. Detection of pulmonary hypertension with multidetector CT and echocardiography alone and in combination. Radiology 2010;254: 609-16.

11- Karazincir S, Balci A, Seyfeli E, Akoglu S, Babayigit C, Akgül F et al. CT assessment of main pulmonary artery diameter. Diagnostic and Interventional Radiology. 2008 Jun 1;14(2):72.

12- Mahammedi A, Oshmyansky A, Hassoun PM, Thiemann DR, Siegelman SS. Pulmonary artery measurements in pulmonary hypertension: the role of computed tomography. Journal of thoracic imaging. 2013 Mar 1;28(2):96-103.

13- Wells JM, Washko GR, Han MK, Abbas N, Nath H, Mamary AJ. et al . Pulmonary arterial enlargement and acute exacerbations of COPD. New England Journal of Medicine. 2012 Sep 6;367(10):913-21.

14- Creasy H. Pulmonary arterial enlargement and acute exacerbations of COPD. Thorax. 2013 Oct 1;68(10):977-..

15- Hayes Jr D, Tobias JD, Mansour HM, Kirkby S, McCoy KS, Daniels CJ, Whitson BA. Pulmonary hypertension in cystic fibrosis with advanced lung disease. American journal of respiratory and critical care medicine. 2014 Oct 15;190(8):898-905.

16- Francone M, Iafrate F, Masci GM, Coco S, Cilia F, Manganaro L et al. Chest CT score in COVID-19 patients: correlation with disease severity and short-term prognosis. Eur Radiol. 2020 Dec;30(12):6808-6817

17- Brower RG, Lanken PN, MacIntyre N, Matthay MA, Morris A, Ancukiewicz M. et al. National Heart, Lung, and Blood Institute ARDS Clinical Trials Network. Higher versus lower positive end-expiratory pressures in patients with the acute respiratory distress syndrome. N Engl J Med. 2004 Jul 22;351(4):327-36.

18- Danzi GB, Loffi M, Galeazzi G, Gherbesi E. Acute pulmonary embolism and COVID-19 pneumonia: a random association?. European heart journal. 2020 May 14;41(19):1858-.

19- Tang N, Bai H, Chen X, Gong J, Li D, Sun Z. Anticoagulant treatment is associated with decreased mortality in severe coronavirus disease 2019 patients with coagulopathy. Journal of thrombosis and haemostasis. 2020 May;18(5):1094-9.

20- Guzik TJ, Mohiddin SA, Dimarco A, Patel V, Savvatis K, Marelli-Berg FM, et al. COVID-19 and the cardiovascular system: implications for risk assessment, diagnosis, and treatment options. Cardiovascular research. 2020 Aug 1;116(10):1666-87.

21- Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. The lancet. 2020 Feb 15;395(10223):507-13..

22- Medford AR. Pulmonary arterial enlargement and COPD exacerbations. The New England journal of medicine. 2012 Dec 1;367(23):2253-4..

23- Lang M, Som A, Mendoza DP, Flores EJ, Reid N, Carey D et al. Hypoxaemia related to COVID-19: vascular and perfusion abnormalities on dual-energy CT. The Lancet Infectious Diseases. 2020 Dec 1;20(12):1365-6.

24- Zhao W, Zhong Z, Xie X, Yu Q, Liu J. Relation Between Chest CT Findings and Clinical Conditions of Coronavirus Disease (COVID-19) Pneumonia: A Multicenter Study. AJR Am J Roentgenol 2020. 214: 1072-1077

25- Xiong M, Liang X, Wei YD. Changes in blood coagulation in patients with severe coronavirus disease 2019 (COVID-19): a meta-analysis. British journal of haematology. 2020 Jun;189(6):1050-2.

26- Zhang Y, Xiao M, Zhang S, Xia P, Cao W, Jiang W, et al. Coagulopathy and antiphospholipid antibodies in patients with Covid-19. New England Journal of Medicine. 2020 Apr 23;382(17): .

27- Hu Q, Pan Y, Sun Z, Xiang M, Xia L, Guan H. Role of pulmonary circulation assessment in CT imaging in evaluating the severity and tendency of severe and critical COVID-19 pneumonia.

28- Leonard-Lorant I, Delabranche X, Severac F, Helms J, Pauzet C, Collange O et al. Acute pulmonary embolism in patients with COVID-19 at CT angiography and relationship to D-dimer levels. Radiology. 2020 Sep;296(3):E189-91.

29- Dolhnikoff M, Duarte-Neto AN, de Almeida Monteiro RA, da Silva LF, de Oliveira EP, Saldiva PH et al. Pathological evidence of pulmonary thrombotic phenomena in severe COVID-19. Journal of Thrombosis and Haemostasis. 2020 Jun;18(6):1517-9.

30- Grillet F, Behr J, Calame P, Aubry S, Delabrousse E. Acute pulmonary embolism associated with COVID-19 pneumonia detected with pulmonary CT angiography. Radiology. 2020 Sep;296(3):E186-8.

31- Lodigiani C, Iapichino G, Carenzo L, Cecconi M, Ferrazzi P, Sebastian T, et al. Venous and arterial thromboembolic complications in COVID-19 patients admitted to an academic hospital in Milan, Italy. Thrombosis research. 2020 Jul 1;191:9-14.

32- Kim S, Kim YH, Lee SH, Kim JS. Pulmonary Vein Enlargement as an Independent Predictor for New-Onset Atrial Fibrillation. Journal of clinical medicine. 2020 Feb;9(2):401.

33- Cardinale L, Priola AM, Moretti F, Volpicelli G. Effectiveness of chest radiography, lung ultrasound and thoracic computed tomography in the diagnosis of congestive heart failure. World journal of radiology. 2014 Jun 28;6(6):230.

34- Chen L, Li X, Chen M, Feng Y, Xiong C. The ACE2 expression in human heart indicates new potential mechanism of heart injury among patients infected with SARS-CoV-2. Cardiovascular research. 2020 May 1;116(6):1097-100.

35- Vancheri F, Longo G, Vancheri S, Henein M. Coronary microvascular

dysfunction. Journal of Clinical Medicine. 2020 Sep;9(9):2880.

36- Ranucci M, Ballotta A, Di Dedda U, Bayshnikova E, Dei Poli M, Resta M, et al. The procoagulant pattern of patients with COVID-19 acute respiratory distress syndrome. Journal of Thrombosis and Haemostasis. 2020 Jul;18(7):1747-51.

37- Thachil J, Tang N, Gando S, Falanga A, Cattaneo M, Levi M, et al. ISTH interim guidance on recognition and management of coagulopathy in COVID-19. Journal of Thrombosis and Haemostasis. 2020 May;18(5):1023-6.

38- Shi H, Han X, Jiang N, Cao Y, Alwalid O, Gu J, et al. Radiological findings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptive study. The Lancet infectious diseases. 2020 Apr 1;20(4):425-34.