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Role of CT Pulmonary Angiography in Correlation of Qanadli Obstruction Index and Atrial Size in Patients with Pulmonary Thromboembolism

Dr Trupthi Das[1]*, Dr Dhaval Kumar Solanki[2], Dr Jeevika Mudagol Ujjappa[3], Dr Kishan Ashok Bhagwat[4]

1. Junior Resident, Department of Radiology, JJM Medical College, Davangere, Karnataka, India. PO- 577004
trupthi8das@gmail.com
2. Junior Resident, Department of Radiology, JJM Medical College, Davangere, Karnataka, India. PO- 577004
djsolanki94@gmail.com
3. Professor, Department of Radiology, JJM Medical College, Davangere, Karnataka, India. PO- 577004
drjeevikamu74@gmail.com
4. Professor, Department of Radiology, JJM Medical College, Davangere, Karnataka, India. PO- 577004
bhagwatkishan@gmail.com

***Corresponding author:**
Dr Trupthi Das, Department of Radiology, JJM Medical College, Davangere, Karnataka, India. PO- 577004
Email: trupthi8das@gmail.com

Abstract

Background: A lethal and life-threatening complication of venous thromboembolism is pulmonary thromboembolism (PTE). Increased burden of clot in the pulmonary arteries would correlate with a decrease in the left atrial size and a relatively increased right atrial size, as measured on CTPA. The presence of these indicators would thus serve as early parameters in assessing the severity of PTE. The aim of the present study was to investigate and prove the correlation between the pulmonary arterial obstruction index (PAOI) and the atrial size in patients with pulmonary thromboembolism.

Methods: The prospective study was conducted for the period of 20 months and 50 cases were included in the study. Patients from tertiary care hospitals were the main source of data for the study. Patients were selected according to inclusion criteria. After obtaining relevant clinical history and consent from the patients, they were subjected to CTPA imaging using a 50 SLICE MDCT SCANNER (REVOLUTION ACT, GE Healthcare). Reconstructed slice thickness was 1.0–2.0mm, with an increment of 0.5- 1mm. The protocol consisted of injection of intravenous contrast of 60mL of iodinated contrast material at a concentration of 300mg iodine /mL (Ultravist; Bayer AG, Berlin, Germany) at a rate of 3- 4 mL/s. All scans were obtained in a caudal-cranial direction at end-of-inspiration during a single breath-hold. The images were then analysed through which PAOI and atrial measurements were correlated using volumetric analyses. Right and left atrial maximum dimensions of their short axis, long axis and area were obtained on axial planes.

Results: 50 patients with pulmonary thromboembolism were enrolled in our study. In this study, 40% of the cases were aged more than 50 years with 66.0% males of the cases. About 70.0% of the cases had no comorbidities, 16.0% had diabetes mellitus and 6.0% had diabetes mellitus with hypertension. The correlation coefficient between short axis Right Atrium (RA) diameter and Qanadli obstruction index (QOI) was 0.616 which was statistically significant. The correlation coefficient between the short axis Left Atrium diameter and QOI was -0.517 which was also statistically significant.

Conclusion: Acute cor pulmonale which is right heart failure caused by increase in pulmonary pressure is related to the clot burden. In our study, there was a negative correlation between left atrial and ventricular dimensions, left atrial / right atrial area, left atrial / right atrial short axis and left atrial / right atrial long axis with the PAOI. There was also a significant positive correlation between right atrial and ventricular dimensions, RA area, PA/ Aorta and RV/LV ratio.

Keywords: Pulmonary arterial obstruction index, Qanadli obstructive index (QOI), Atrial size, Pulmonary thromboembolism

1. BACKGROUND

A lethal and life-threatening complication of venous thromboembolism is pulmonary thromboembolism (PTE) [1]. The venous thromboembolism usually manifests either in the form of pulmonary embolism (PE) or deep vein thrombosis (DVT) [2,3]. The PE presents with acute pulmonary obstruction by an embolus and in 95% of the cases, the embolus originates from the deep veins of the lower extremity, most often the popliteal vein and veins above it

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or from the venous plexuses of the pelvis. In the rest, emboli originate from the right heart cavities, some other veins or in situ pulmonary artery thrombosis [4].

The common manifestations of the PE include dyspnea, chest pain and cough while clinical picture is characterized by fever, tachycardia, abnormal pulmonary signs and peripheral vascular collapse [5]. The final diagnosis of PE is made by computed tomography pulmonary angiogram (CTPA) with evaluation of ventilatory failure. The diagnosis of PE can be made on the basis of auscultation of the lungs, auscultation of the heart, laboratory findings, monitoring of oxygen saturation, prediction, findings on thoracic radiography, electrocardiogram, transthoracic echo and CTPA [6,7]. Based on its capacity to assess RV size, systolic function, pressure, volume, and RV wall motion, echocardiography (ECHO) is advised as the initial examination to diagnose the symptoms of Right Ventricular Dysfunction (RVD) [8]. RVD is characterized by an enlarged right ventricle (RV), a straightened interventricular septum, an increased ratio of the diameter of the pulmonary artery to the diameter of the ascending aorta (PA/Ao), an increased diameter of the superior vena cava (SVC) and reflux of intravenous contrast material into the inferior vena cava (IVC) and hepatic veins [9,10].

There are studies with a small patient population that directly compare the results of computed tomography pulmonary angiography (CTPA) with those of ECHO in the literature. It is proved that Computed Tomography Pulmonary Angiography (CTPA) is an invaluable first line diagnostic tool in early identification of PTE [7,11]. Preliminary studies have suggested the correlation between atrial size and clot burden present in the pulmonary arteries in patients with PTE [1,11]. The clot burden is calculated by applying the CTPA dependent score– Qanadli obstructive index (QOI) in the pulmonary arteries [7]. An increased burden of clot in the pulmonary arteries would correlate with a decrease in the left atrial size and a relatively increased right atrial size, as measured on CTPA [1]. The presence of these indicators would thus serve as early parameters in assessing the severity of PTE [11]. Hence, this study intends to investigate and prove the correlation between the PAOI and the atrial size in patients with PTE.

2. METHODS

Study design

The prospective study was conducted for the period of 20 months and 50 cases were included in the study. Patients from tertiary care hospitals attached to JJM Medical college were the main source of data for the study.

Consent for publication

All patients gave written informed consent to publish the data contained within this study.

Inclusion criteria

Patients referred/admitted to the institution with clinical suspicion of PTE.

Exclusion criteria

1) Patients with known or suspected allergy to contrast media
2) Patients with serum creatinine >1.5 mg/dL / eGFR < 30 mL/min/1.73m2.
3) Patients with severe PE requiring urgent thrombolytic therapy.

Method of collection of Data (including sampling procedures if any)

Patients were selected according to inclusion criteria. After obtaining relevant clinical history and consent from the patients, they were subjected to CTPA imaging using a 50 SLICE MDCT SCANNER (REVOLUTION ACT, GE Healthcare). Reconstructed slice thickness was 1.0–2.0mm, with an increment of 0.5- 1mm. The protocol consisted of injection of intravenous contrast of 60mL of iodinated contrast material at a concentration of 300mg iodine /mL (Ultravist; Bayer AG, Berlin, Germany) at a rate of 3- 4 mL/s. All scans were obtained in a caudal-cranial direction at end-of-inspiration during a single breath-hold. The images were then analysed through which PAOI and atrial measurements were correlated using volumetric analyses.

Right and left atrial maximum dimensions of their short axis, long axis and area were obtained on axial planes (Figure 1). QOI was calculated by the formula of Σ (n.d)/40×100 where n = the number of segmental branches arising distally (minimum, 1; maximum, 20) and d = degree of obstruction (minimum, 0; maximum, 2). Values for n ranged from a minimum of 1 (one segment obstructed) to a maximum of 20 (obstruction of both the right and left pulmonary arteries). Values for d were assigned to provide information about the perfusion distal to the embolus. Partial obstruction is scored 1 and complete obstruction is scored 2 for degree of obstruction (d) while patent lumen is scored 0.

Statistical methodology

Using a region-of-interest (ROI) based approach depending on the anatomic landmarks, QOI and Atrial sizes were measured in pulmonary arteries and left and right atria respectively. The data derived from the volumetric analyses of CTPA was then evaluated longitudinally. Data were entered in the Microsoft Excel sheet and statistical analysis was done using IBM SPSS Statistics V23.0. All results were expressed as mean ± SD/ frequency/ percentage. A Chi –square test/ Cramer's V test will be used to correlate the values of the QOI and atrial sizes and test its significance (significant with $p < 0.05$) in the evaluation of patients with varying severity of PTE.

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

3. RESULTS

This non-randomized, observational, cross-sectional study was conducted in a tertiary care hospital attached to JJM Medical college in India from March 2021 to October 2022. This study enrolled 50 Indian patients who underwent CT pulmonary angiography for PTE.

Demographics and baseline clinical characteristics of the study population

This study had shown that about 40.0% of the cases were aged more than 50 years and 36.0% of the cases were aged between 31to 50 years (Table 1). About 66.0% of the cases were males and 36.0% were females in this study (Table 2). About 70.0% of the cases had no comorbidities, 16.0% had diabetes mellitus and 6.0% had diabetes mellitus with hypertension. About 16.0% of the cases were smokers in this study. About 58.0% of the cases in this study presented with breathlessness followed by chest pain in 12.0% of the cases.

The correlation coefficient between the long axis LA/RA and QOI was -0.654 and it was statistically significant (Figure 2). The correlation coefficient between short axis LA/RA and QOI was -0.731 and it was statistically significant (Figure 3). The correlation coefficient between the LA/RA area and QOI was -0.322 which was also statistically significant (Figure 4). The correlation coefficient between the RV/LV ratio and QOI was 0.388 which was statistically significant (Figure 5).

4. DISCUSSION

PTE is a potentially fatal and life-threatening variant of venous thromboembolism [1]. The venous thromboembolism usually manifest either in the form of PE or DVT [2,3]. The presence of these indicators would thus serve as early parameters in assessing the severity of PTE [12]. There have been a meagre amount of studies which have done research on this particular topic [1,12]. Moreover, there have been no cognizable study of this kind to have been done in the Indian subcontinent. Hence, this study intends to investigate and prove the correlation between the PAOI and the atrial size in patients with PTE. Stein et al reported that, in a tertiary care general hospital, the incidence of acute PE by age, sex, and race revealed a linear relationship between the incidence of acute PE to age, as is seen in this study [13].

In our study, about 40.0% of the cases were aged more than 50 years (Table 1). A study by Langroudi et al reported that, the mean age of the cases with PE was 58.3 years similar to the results of this study.1 About 66.0% of the cases were males in this study (Table 2). A study by Aviram et al had shown that, about 66.0% of the cases were females in their study [12]. About 70.0% of the cases had no comorbidities, 16.0% had diabetes mellitus and 6.0% had diabetes mellitus and hypertension. A study by Aviram et had shown that, about 10% of the cases had diabetes mellitus, 25.0% had hypertension and 3% had dyslipidemia [12]. About 16.0% of the cases were smokers in this study. In a study by Aviram et al, about 3.0% of the cases were current smokers [12].

The correlation coefficient between short axis RA diameter and QOI was 0.616 which was statistically significant (Table 3). The correlation coefficient between the short axis LA diameter and QOI was -0.517 which was also statistically significant (Table 3). A study by Aviram et al had shown a significantly negative correlation of pulmonary artery obstruction index with LA short axis diameter. The correlation coefficient was positive and significant with RA short axis diameter [12]. A study by Langroudi et al noted that, there was negative correlation with the QOI for LA and positive and significant correlation for the RA short diameter with obstruction index [1]. A study by Dakshin had reported significant negative Left Ventricle (LV) correlation and significantly positive correlation of RA with QOI [14].

The correlation coefficient between the long axis RA diameter and QOI was 0.592 which was statistically significant (Table 3). The correlation coefficient between the long axis LA diameter and QOI was -0.296 which was statistically significant (Table 3). A study by Aviram et had shown that, the obstruction index had shown a non-significantly positive correlation with LA long axis and significantly positive correlation with the RA long axis diameter [12].

The correlation coefficient between the long axis LA/RA and QOI was -0.654 and it was statistically significant (Table 3, Figure 2). A study by Aviram et al had noted that, there was negative correlation between the obstruction index and LA/RA long diameter ratio [12]. A study by Langroudi et al noted that, there was positive but not significant association of RA to LA long diameter with obstruction index [1]. A study by Dakshin et al noted a negative and significant correlation with long axis LA/RA ratio [14].

The correlation coefficient between short axis LA/RA and QOI was -0.731 and it was statistically significant (Table 3, Figure 3). A study by Aviram et al noted that, there was a positive and significant correlation of obstruction index with the LA/ RA short axis diameter [12]. A study by Langroudi et al noted that, there was positive and significant correlation of RA to LA short diameter ratio with the obstruction index [1]. A study by Dakshin et al noted a negative and significant correlation with LA/RA short axis ratio [14].

The correlation coefficient between the LA/RA area and QOI was -0.672 which was statistically significant (Table 3, Figure 4). There was significantly negative LA/RA ratio of obstruction index with the LA/RA area [12]. A study

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

by Langroudi et al had noted that, a positive and significant correlation of RA to LA area with the obstruction index [1]. A study by Dakshin et al noted a negative and significant correlation with the obstruction index [14].
The correlation coefficient between the RV/LV ratio and QOI was 0.388 which was statistically significant (Figure 5). A study by van der Meer et al had shown that, CT signs of RVD (RV/LV ratio of more than 1 was seen in 57.5% of the cases. This study also noted that, both RV/LV ratio and obstruction index were shown to be the risk factors of mortality within 3 months [15].
This study has shown a positive and significant correlation of QOI with RA short axis diameter, RA long axis diameter, RA area, RV/LV ratio. It showed negative and significant correlation with LA short axis diameter, LA long axis diameter, LA area, LA/RA long axis ratio, LA/RA short axis ratio and LA/RA area. This study is not without limitations. The sample size used is convenience sampling and hence the results cannot be generalized. But this study was able to bring out important facts about the association of QOI with many CTPA parameters.
The atrial dimensions along with other parameters can serve as parameters which reflect changes in the cardiac morphology. This is in response to the clot burden within the pulmonary arteries. Thus, these parameters help to intervene early and prevent cardiac failure in patients with acute pulmonary thrombo-embolism.

5. CONCLUSIONS

Acute cor pulmonale which is right heart failure caused by increase in pulmonary pressure is related to the clot burden. In our study, there was a negative correlation between left atrial and ventricular dimensions, left atrial / right atrial area, left atrial / right atrial short axis and left atrial / right atrial long axis with the PAOI. There was also a significant positive correlation between right atrial and ventricular dimensions, RA area, PA/ Aorta and RV/LV ratio. The atrial dimensions reflect changes in the cardiac morphology in response to the clot burden. These parameters help to intervene early and prevent cardiac failure in patients with acute pulmonary thrombo-embolism.

List of abbreviations

AO	-	Ascending Aorta
CTPA	-	CT Pulmonary Angiography
DVT	-	Deep Vein Thrombosis
ECHO	-	Echocardiography
eGFR	-	Estimated Glomerular Filtration Rate
GE	-	General Electronics
IVC	-	Inferior Vena Cava
LA	-	Left Atrium
LV	-	Left Ventricle
MDCT	-	Multi Detector Computed Tomography
PA	-	Pulmonary Artery
PAOI	-	Pulmonary Arterial Obstruction Index
PE	-	Pulmonary Embolism
PTE	-	Pulmonary Thromboembolism
QOI	-	Qanadli Obstruction Index
RA	-	Right Atrium
ROI	-	Region of Interest
RV	-	Right Ventricle
RVD	-	Right Ventricular Dysfunction
SVC	-	Superior Vena Cava

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ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

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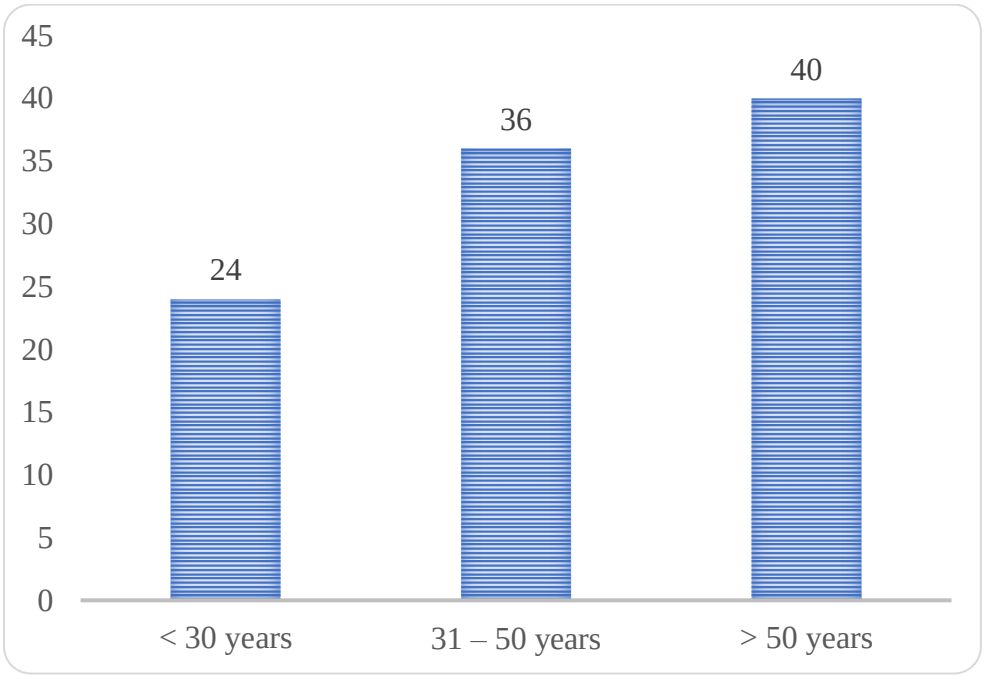

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

Table 1: Age-wise distribution of the patients with pulmonary thromboembolism.

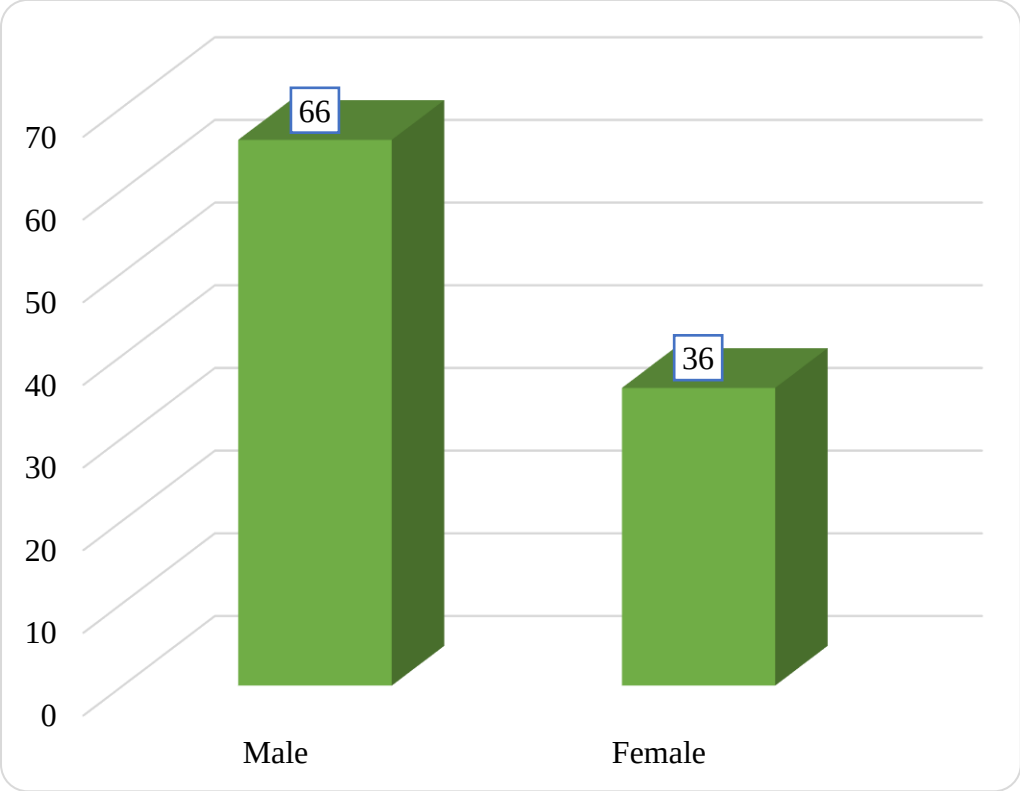

Table 2: Sex-wise distribution of patients with pulmonary thromboembolism.

		QOI	
		r value	**p value**
Short axis	**RA Diameter**	0.616	0.000, Sig
	LA Diameter	-0.517	0.021, Sig
Long axis	**RA Diameter**	0.592	0.000, Sig
	LA Diameter	-0.296	0.037, Sig
Area	**RA Diameter**	0.474	0.001, Sig
	LA Diameter	-0.322	0.023, Sig
Long axis	**LA/RA**	-0.654	0.000, Sig
Short axis	**LA/RA**	-0.731	0.000, Sig
Area	**LA/RA**	-0.322	0.023, Sig

Sig= significant

Table 3: Pearson's correlation of QOI with dimensions of RA and LA

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

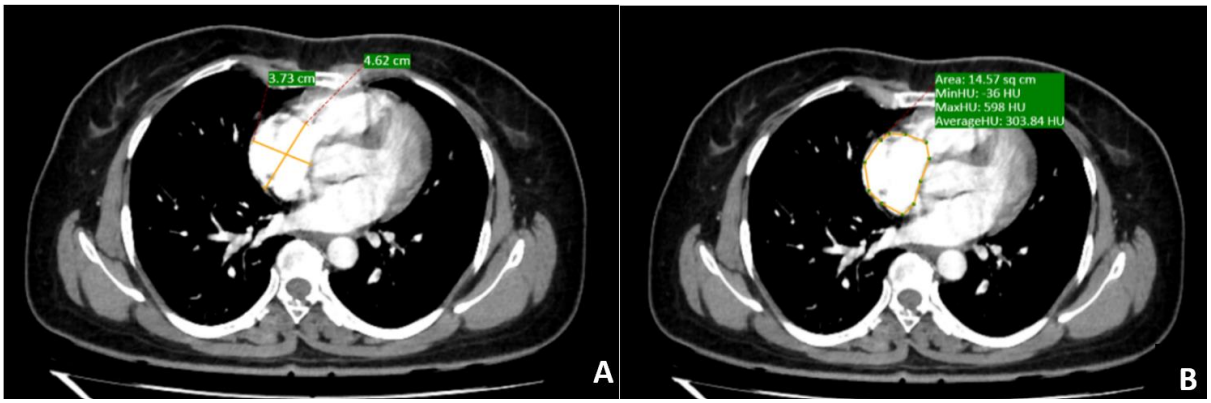

Figure 1: Measurements of maximum dimensions of short axis, long axis (A) and area (B) of right atrium obtained on axial plane.

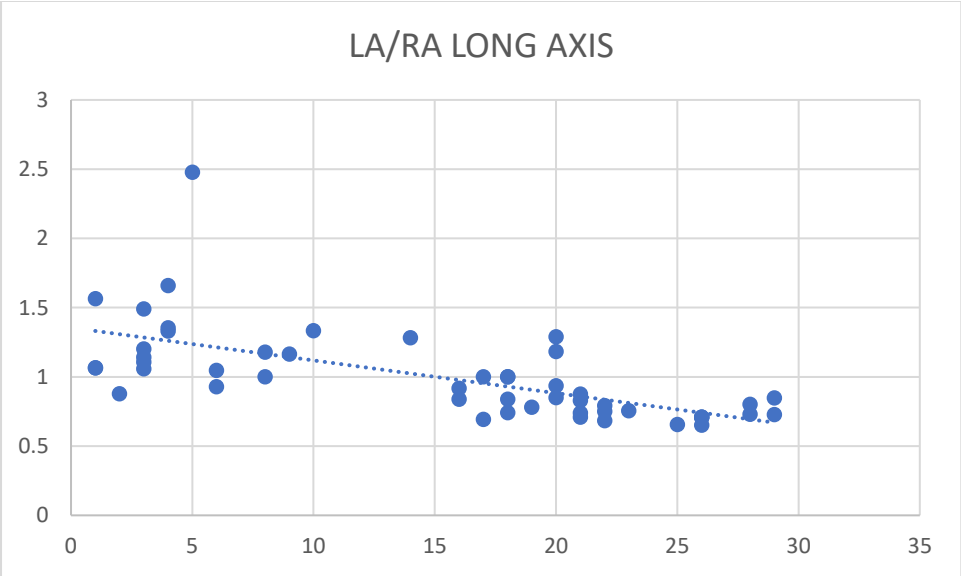

Figure 2: Correlation of long axis LA/RA and Qanadli obstruction index

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

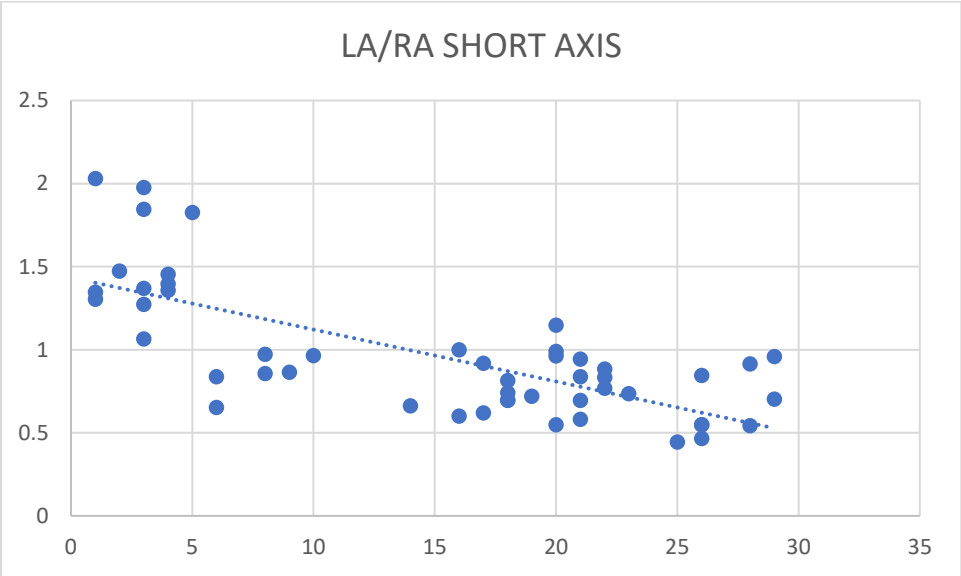

Figure 3: Correlation of short axis LA/RA and Qanadli obstruction index

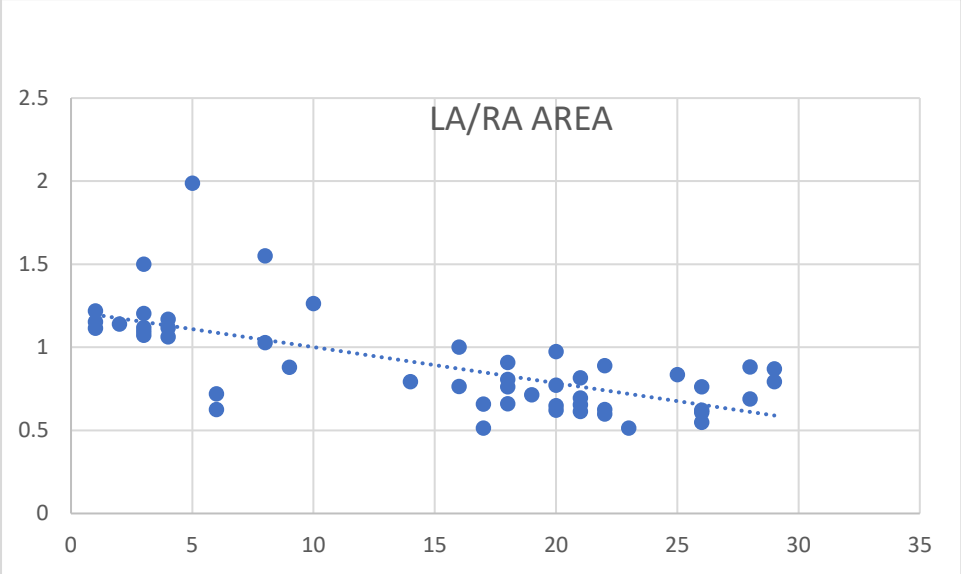

Figure 4: Correlation of LA/RA area and Qanadli obstruction index

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

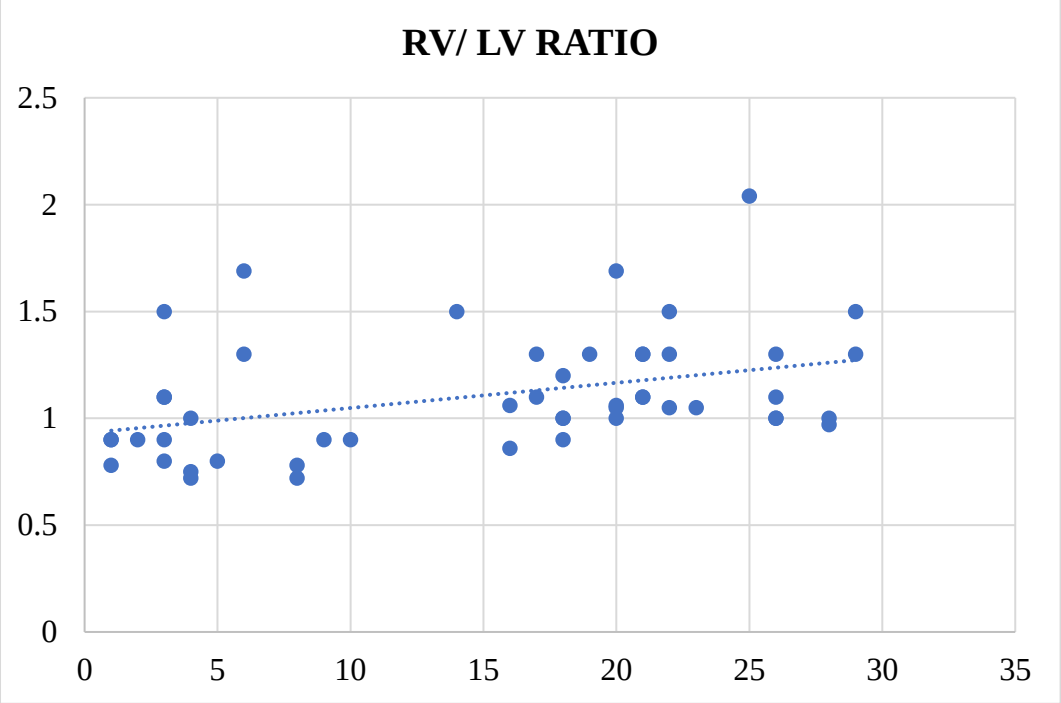

Figure 5: Correlation of RV/LV short axis and Qanadli obstruction index

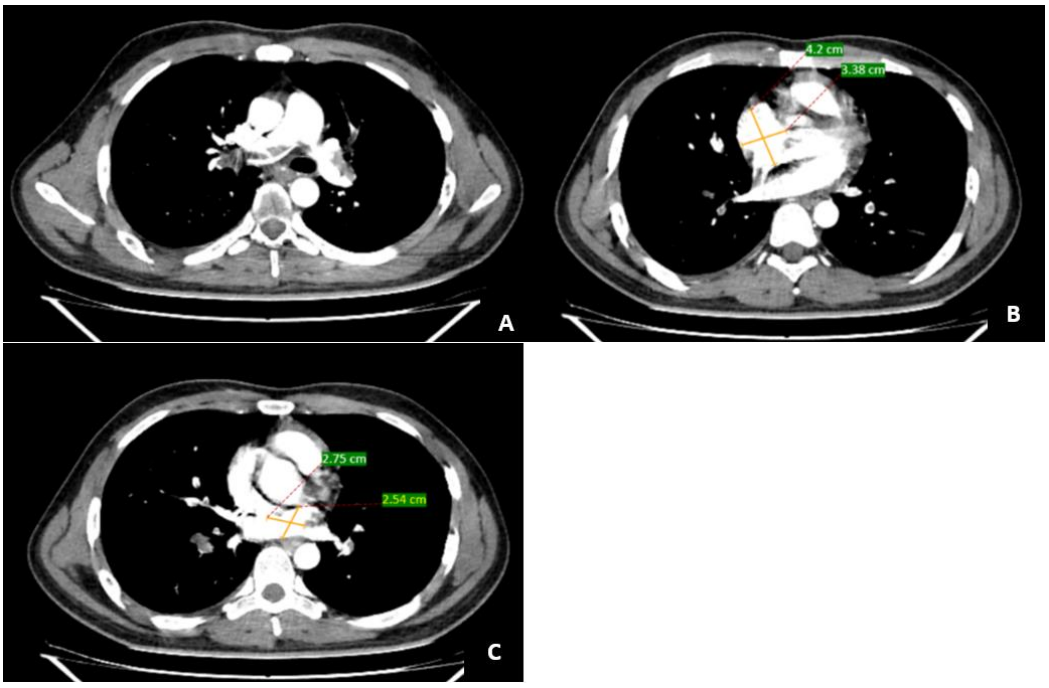

Figure 6: 25 years old male with acute onset of breathlessness and cough for 2 days.
A. CTPA showing saddle thrombus. **B.** Right atrial dilatation with dimensions. **C.** Left atrial dimensions.

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

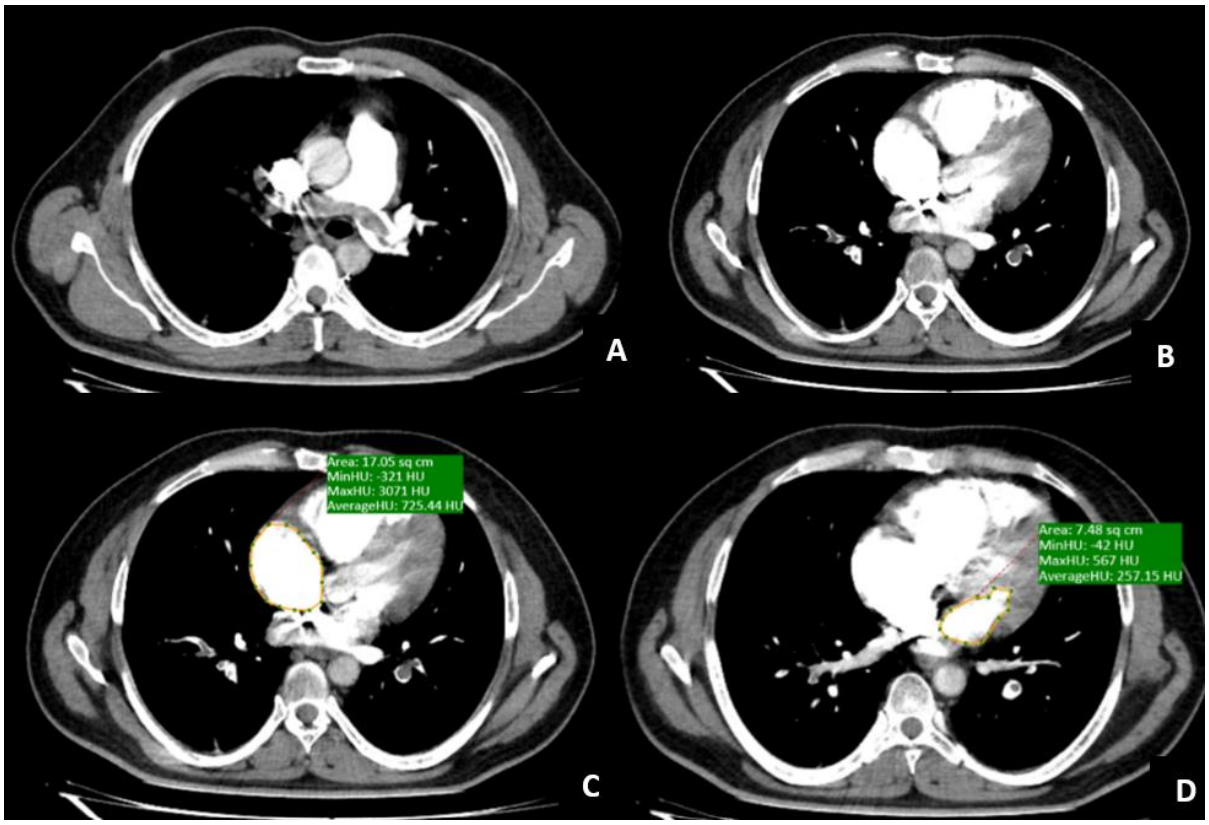

Figure 7: 50 years old male with acute onset of breathlessness and chest pain.
A. CTPA showing saddle thrombus. **B.** Thrombi in segmental arteries. **C.** Right atrial area.
D. Left atrial dimensions.

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

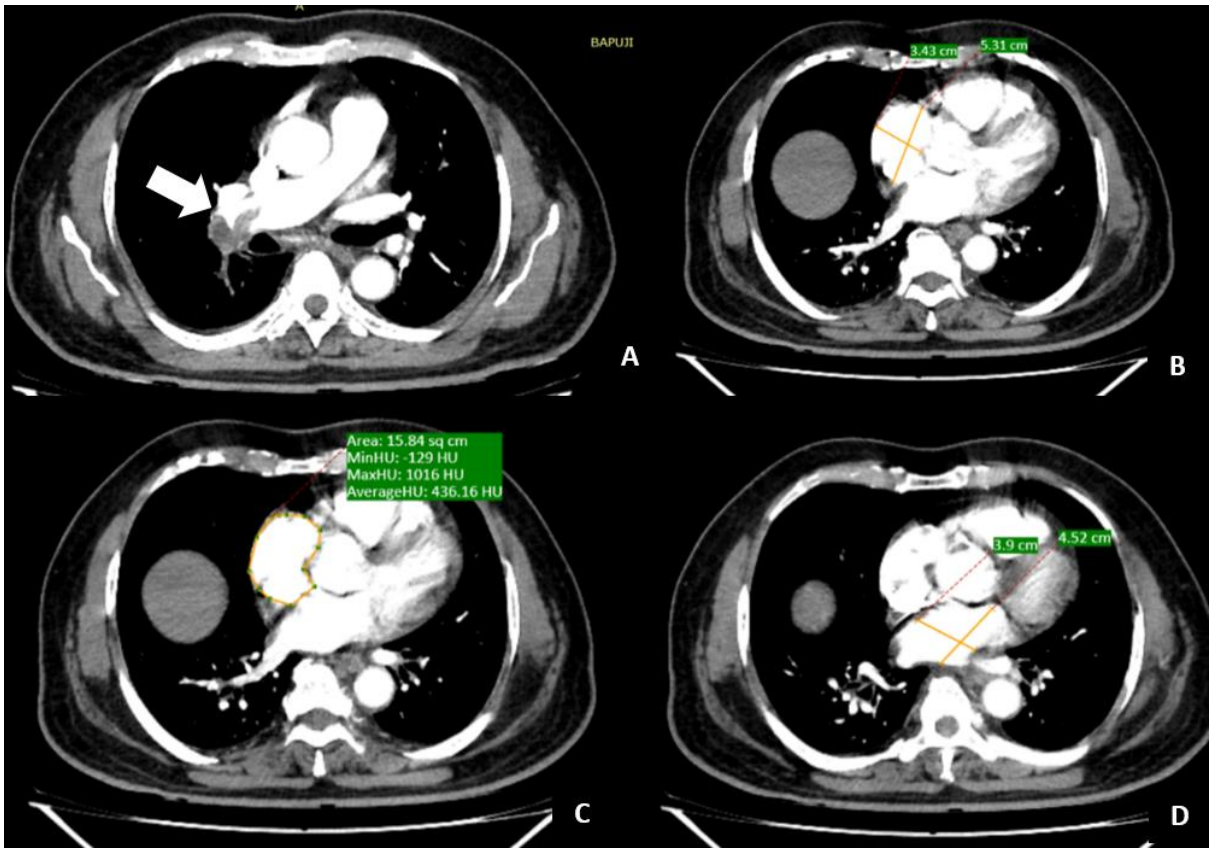

Figure 8: 72 years old male with acute onset of breathlessness.
A. CTPA showing thrombus in right pulmonary artery (arrow). **B, C.** Right atrial dimensions. **D.** Left atrial dimensions.