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Assessment of Pulmonary Embolism Severity and Scoring Using Multi Slice CT in Correlation with Clinical Presentation and Echocardiography

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ABSTRACT

Aim of the work: The aim of this study is to evaluate the correlation between pulmonary embolism severity and scoring obtained using multi slice CT (MSCT) and the clinical presentations and echocardiography in patients with pulmonary embolism (PE). **Patients and method**: this study was carried out in the Radiology Department of Ain Shams University Hospitals. 21 patients with PE. The CT obstruction index (OI) using Qanadli score and the RV/LV diameter Right ventricle dysfunction ratio (RVD-ratio) using the four-chamber view of the heart were calculated for all patients. The cut-off for the OI to detect RVD was constructed using ROC curve. They were 13 (61.9%) females and 8 (38.1%) males. Their age was ranged from 22 -83 years old. R**esults:** Dyspnea and RVD (RVD-ratio >1) were significantly more common in patients with severe pulmonary embolism. Regarding the echo findings with PE high Right ventricular systolic pressure (RVSP) was the commonest echo finding among our studied patients. The cutoff point of obstruction index (OI) >15 (Qanadli score >37.5 %) has the highest prediction value of right ventricular dysfunction, indicating that most of the patients with a score of more than 37.5% had RVD that was agreed with echo findings.

Keywords: MSCT, OI, ECHO.

INTRODUCTION

Acute pulmonary embolism (PE) is a common and potentially fatal disease with mortality ranging from 2% to 7%, even when treated with anticoagulation[(1)].

Symptoms and signs of PE are often non-specific, and clinical presentation of patients with suspected PE varies widely making it hard to diagnose or exclude PE. Although PE cannot be diagnosed or excluded on clinical grounds, clinical suspicion (pretest probability) of PE guides the further diagnostic process[(2)] .

Echocardiography can be used as an easy, inexpensive, devoid of complications and, for the most part, universally available tool for the risk stratification of patient with acute pulmonary embolism. Because of its low sensibility, an echocardiogram is best indicated in a patient in whom hypotension and or shock are suspected to be due to pulmonary embolism. Pertinent findings in the echocardiogram can justify the use of fibrinolytic therapy. Most common echocardiographic findings in acute pulmonary embolism are: dilatation of the right ventricle, right ventricular dysfunction in some cases with preservation of the motility of the apex, dilatation of the inferior vena cava with lack of collapse during inspiration flattening of the interventricular septum suggesting right ventricular pressure overload and pulmonary hypertension based on the jet of tricuspid regurgitation if available[(3)].

The advantage of multidetector computed tomography (MDCT) pulmonary angiography, particularly 16- and 64-slice made volumetric acquisition of images of the entire chest in a single breath-hold with isotropic resolution possible. This capability enables multiplanar viewing and assessment of pulmonary vessels to sub-segmental levels. All these advantages made MDCT angiography the most commonly used procedure for the diagnosis of PE[(4)].

It is important to show the relationship between the CT obstruction index (OI) and other parameters (e.g. those recently used in stratification of patient risk, such as the right ventricular dilatation). The presence of RVD may indicate a high likelihood of recurrent and possibly fatal PE, despite an adequate anticoagulation therapy. The degree of pulmonary vascular obstruction is considered the most important factor determining the right ventricular impairment in patients with PE[(5)] **.**Computed tomography pulmonary angiography (CTPA) is the current reference standard for confirming suspected acute PE. Thus, CTPA is performed in nearly all patients with suspected PE if they have no contraindications to iodinated contrast agents. In addition to detecting emboli, CTPA enables evaluation of right ventricular (RV) dysfunction, including the right-to-left ventricular (RV/LV) diameter ratio, and interventricular septal bowing, some of which are associated with high mortality rates and PE-related adverse events[(6)].

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PATIENTS AND METHOD

Study included 21 patients who presented to the department of radiology at Ain Shams University with suspected pulmonary embolism & CT pulmonary angiography was requested for them. **The study was approved by the Ethics Board of Ain Shams University.**

Inclusion criteria:

Patients undergoing CT pulmonary angiography for evaluation of pulmonary embolism

Exclusion criteria:

1. Patients proven not to have pulmonary embolism with CTA criteria.
2. Patients not suitable for intra venous injection of contrast media (impaired renal function, known allergy for contrast media).
3. Pregnant females
4. Patients < 18 years

All patients were subjected to the following:-

A- Proper history taking and identification of clinical presentation

B- Echocardiography for all patients included in the study

C- Imaging procedure MDCT with post processing MDCT techniques mainly (MPR, MIP).

D- Informed consent was taken before CT examination in prospective cases and ethical committee from our institute approved to use the data in retrospective cases.

The MDCT findings were correlated with the clinical presentations and echocardiography of the patients.

MSCT pulmonary angiography examination and imaging acquisition.

MDCT pulmonary angiography was performed using 64 &16 slice MDCT (GE Healthcare - BrightSpeed) at the Radiology Department.

The clot burden in the pulmonary vascular tree was quantified using Qanadli score to calculate the obstruction index. The RVD ratio and the main pulmonary artery diameter were determined**.**

All patients were fasting for 6 hours before the examination.

Scanning protocol

*** *Patient position:* supine**

*** Scanogram**

*** *Anatomical coverage:* area from supra aortic trunks to the base of lungs.**

The scan was performed from cranial to caudal direction. The MDCT was carried out at 120 kVp, 200 MAs with 0.75 mm collimation and a pitch of 1.22. Images were reconstructed with thickness of 1.25 mm & reconstruction interval of 0.07 mm.

The Standard protocol used for patients is to receive 80 ml of nonionic iodinated contrast medium (ultravist 370) via antecubital vein at rate of 4 ml/sec. 20 ml of normal saline were injected at the same rate before and after contrast injection to check the IV line for extravasation and as a wash out of bolus respectively. The scanning delay was determined using the bolus tracking technique in the lumen of the pulmonary trunk. The threshold value was selected at 120 HU.

All patients given the IV contrast should have normal serum creatinine.

All CTPA images were transferred from picture archiving and communication system (PACS).

The images were interpreted on an independent workstation blinded to patients' clinical presentations or their echocardiography findings, which were remolded afterwards and compared.

Statistical Analysis :

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data were presented as mean, standard deviations and ranges when their distribution found parametric while nonparametric data were presented as median with inter-quartile range (IQR). Also qualitative variables were presented as number and percentages .The comparison between groups with qualitative data were done by using Chi-square test and Fisher exact test instead of the Chi-square only when the expected count in any cell was found less than 5 .The comparison between two groups with quantitative data and parametric distribution was done by using Independent t-test while nonparametric data were done by using Mann-Whitney test .Receiver operating characteristic curve (ROC) was used to assess the diagnostic accuracy with sensitivity, specificity, positive predictive value and negative predictive value . The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as following : $P > 0.05$: Non significant , $P < 0.05$: Significant & $P < 0.01$: Highly significant**. RESULTS:** A total of 21 patients were proven to have PE. They were 13 (61.9%) females and 8 (38.1%) males. Their age ranged from 22 -83 years old.

Age: The age of the study group ranged from 22 to 83 years with 56.29 + 18.9 years mean age +SD (table 4). The female patients comprised the majority of our cases representing 61.9% of the cases

Table 1 shows: The relation between age, sex, clinical presentation and pulmonary thrombus distribution of our studied group with significant and non-significant Qanadli severity score**.**

		Non-significant No. = 15		Significant No. = 6		Test value	P-value	Sig.
Age (years)	Mean±SD Range	54.73 ± 20.61 22 – 83		60.17 ± 14.62 36 – 74		-0.585•	0.565	NS
Clinical Presentation		**Non-significant**		**Significant**		**Test value***	**P-value**	**Sig.**
		No.	**%**	**No.**	**%**			
Chest pain	negative positive	7 8	46.7% 53.3%	1 5	16.7% 83.3%	1.636	0.201	NS
Dyspnea	negative positive	4 11	26.7% 73.3%	1 5	16.7% 83.3%	0.236	0.627	NS
Tachycardia	negative positive	13 2	86.7% 13.3%	3 3	50.0% 50.0%	3.176	0.075	NS
Tachypnea	negative positive	14 1	93.3% 6.7%	5 1	83.3% 16.7%	0.497	0.481	NS
Hemoptysis	negative positive	15 0	100% 0.0%	6 0	100% 0.0%	NA	NA	NA
Distribution of the thrombus		**Non-significant**		**Significant**		**Test value***	**P-value**	**Sig.**
		No.	**%**	**No.**	**%**			
Main trunk	negative positive	15 0	100% 0.0%	5 1	83.3% 16.7%	2.625	0.105	NS
Right main	negative positive	14 1	93.3% 6.7%	2 4	33.3% 66.7%	8.505	0.004	HS
Left main	negative positive	15 0	100% 0.0%	1 5	16.7% 83.3%	16.406	0.001	HS
Lobar	negative positive	5 10	33.3% 66.7%	3 3	50.0% 50.0%	0.505	0.477	NS
Segmental	negative positive	8 7	53.3% 46.7%	5 1	83.3% 16.7%	1.636	0.201	NS

Table 2: Illustrates the relation between Echo findings with pulmonary embolism severity measured using Qanadli system

Echo findings		**Non-significant**		**Significant**		**Test value***	**P-value**	**Sig.**
		No.	**%**	**No.**	**%**			
Dilated right ventricle	Negative Positive	12 3	80.0% 20.0%	1 5	16.7% 83.3%	7.289	0.007	HS
Right ventricle dysfunction	Negative Positive	15 0	100.0% 0.0%	3 3	50.0% 50.0%	8.750	0.003	HS
Right ventricular systolic pressure (RVSP)	Negative Positive	11 4	73.3% 26.7%	0 6	0.0% 100.0%	9.240	0.002	HS

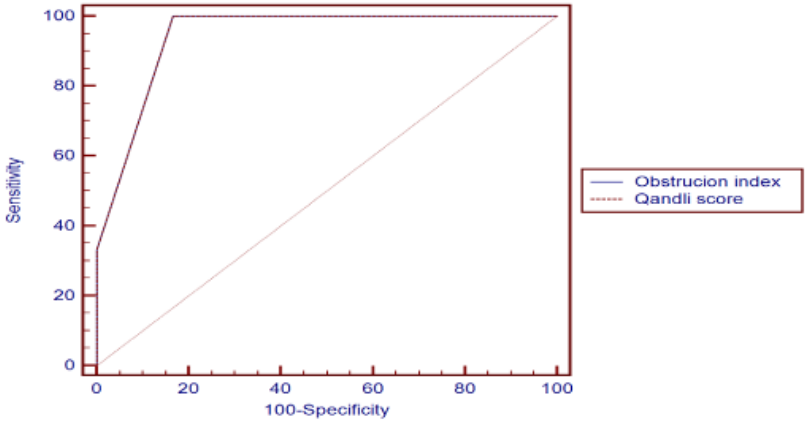

Fig 1: Linear graph showing the Diagnostic accuracy of severity score in prediction of right ventricle dysfunction.

CASES

- **CASE 1:** Female patient, 74 years old, presented by dyspnea, chest pain and tachypnea. Her echo reveals RVSP 65 mm Hg denoting pulmonary hypertension & dilated right ventricle with right ventricular dysfunction.
- MSCT pulmonary angiography (Fig (2) A-F) showing:-
- Hypo-dense filling defect seen partially occluding the right main pulmonary artery and also seen partially occluding the left upper lobar, lingular and the left lower lobar arteries (A-D).
- Qanadli obstruction index was 20 & Qanadli score = 50 %
- Pulmonary artery (E) shows increased diameter reaching 35 mm suggestive pulmonary hypertension.
- The right ventricle is enlarged with RT to LT ratio more than 1 (F)**.**
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Fig (2): pulmonary embolism (A-B) Axial images. (C) Coronal image. (D) Sagittal image. (E) PA diameter. (F) RT to LT ventricular ratio.

CASE 2: Male patient, 56 years old, presented by acute onset of dyspnea and chest pain. Positive Deep vein thrombosis (DVT).

- ❖ MSCT pulmonary angiography (Fig (3) A-E) showing:-
  - Hypo-dense filling defects seen totally occluding the left main pulmonary artery (A, B & C) and partially occluding the right upper and lower lobar branches (A).
  - Qanadli Obstruction index was 28 & Qanadli score = 70 %
  - The pulmonary artery measuring 40 mm suggestive pulmonary hypertension (D).
  - Right ventricle to left ventricle ratio is more than 1 denoting right ventricular strain (E).
  - Septum is central & no reflux in IVC
- ❖ **Echo findings** : RVSP 70 & right ventricular dysfunction with spared apex (Positive McConnell's sign).

Obstruction index & score beside the hemodynamic effects denote severe form of PE that is also evident on ECHO findings.

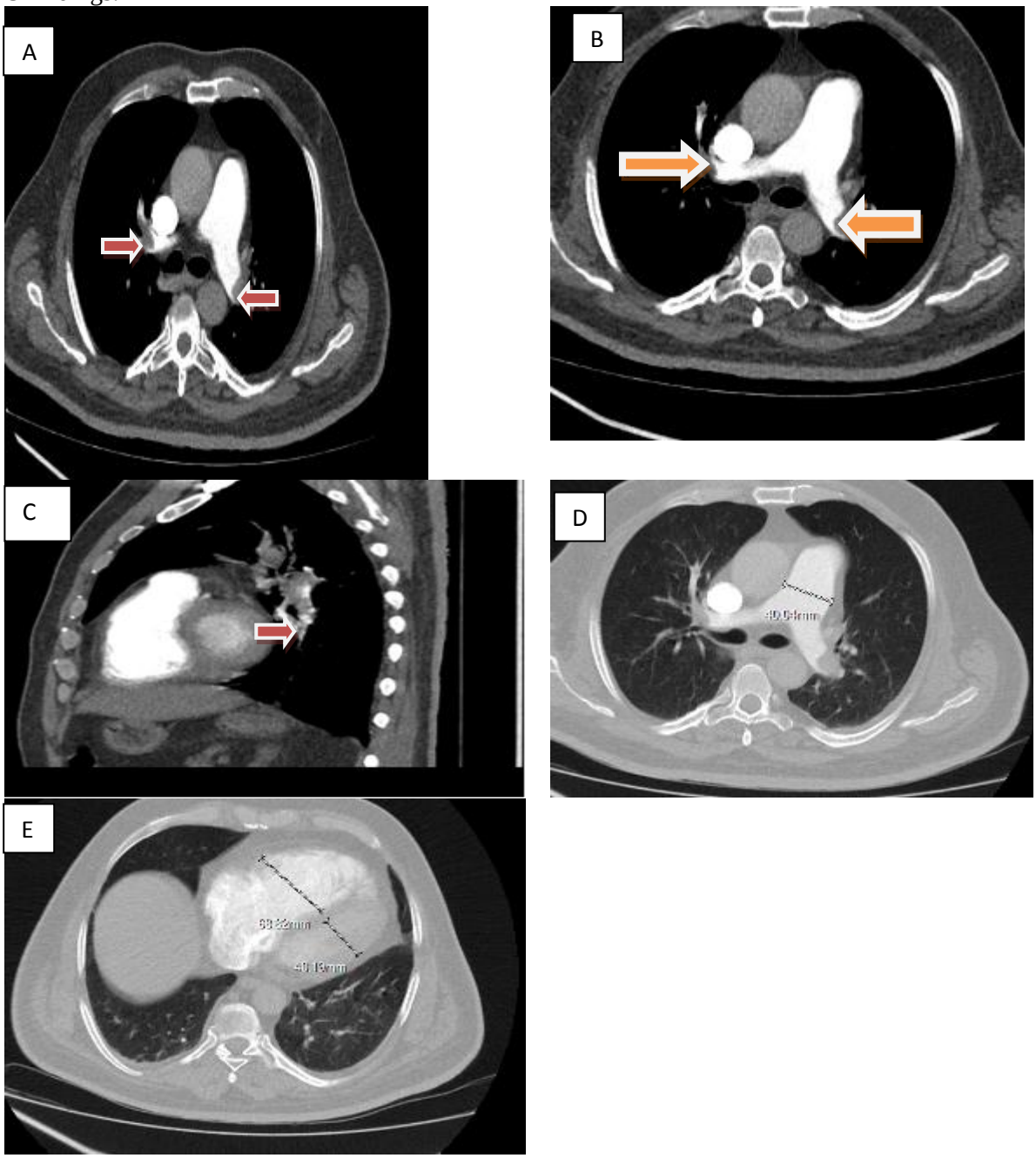

Fig (3): pulmonary embolism (A-B) Axial images. (C) Sagittal images. (D) PA diameter. (E) RT to LT ventricular ratio**.**

CASE 3: Female patient, 49 years old, presented by acute onset of dyspnea and chest pain, Positive DVT with History of previous attack of pulmonary embolism.

- ❖ MSCT pulmonary angiography (Fig (4) A-F) showing:-
- Hypo-dense filling defect (saddle thrombus) seen partially occluding the main pulmonary artery extending to right and left branches.
- Qanadli Obstruction index was 20 & Qanadli score = 50 %
- Associated with enlarged pulmonary artery measuring 34.9 mm (D), enlarged right ventricle with increased ratio between right and left ventricle more than 1 with septum deviation to the left side denoting right ventricular strain (E).
- IVC shows positive reflux of contrast inside (F).
- ❖ **Echo findings** : RVSP 70 mmHg denoting pulmonary hypertension associated with right ventricular dysfunction.

Obstruction index and score and other CT severity parameters show severe form of PE and echo findings are concomitant with CT results .

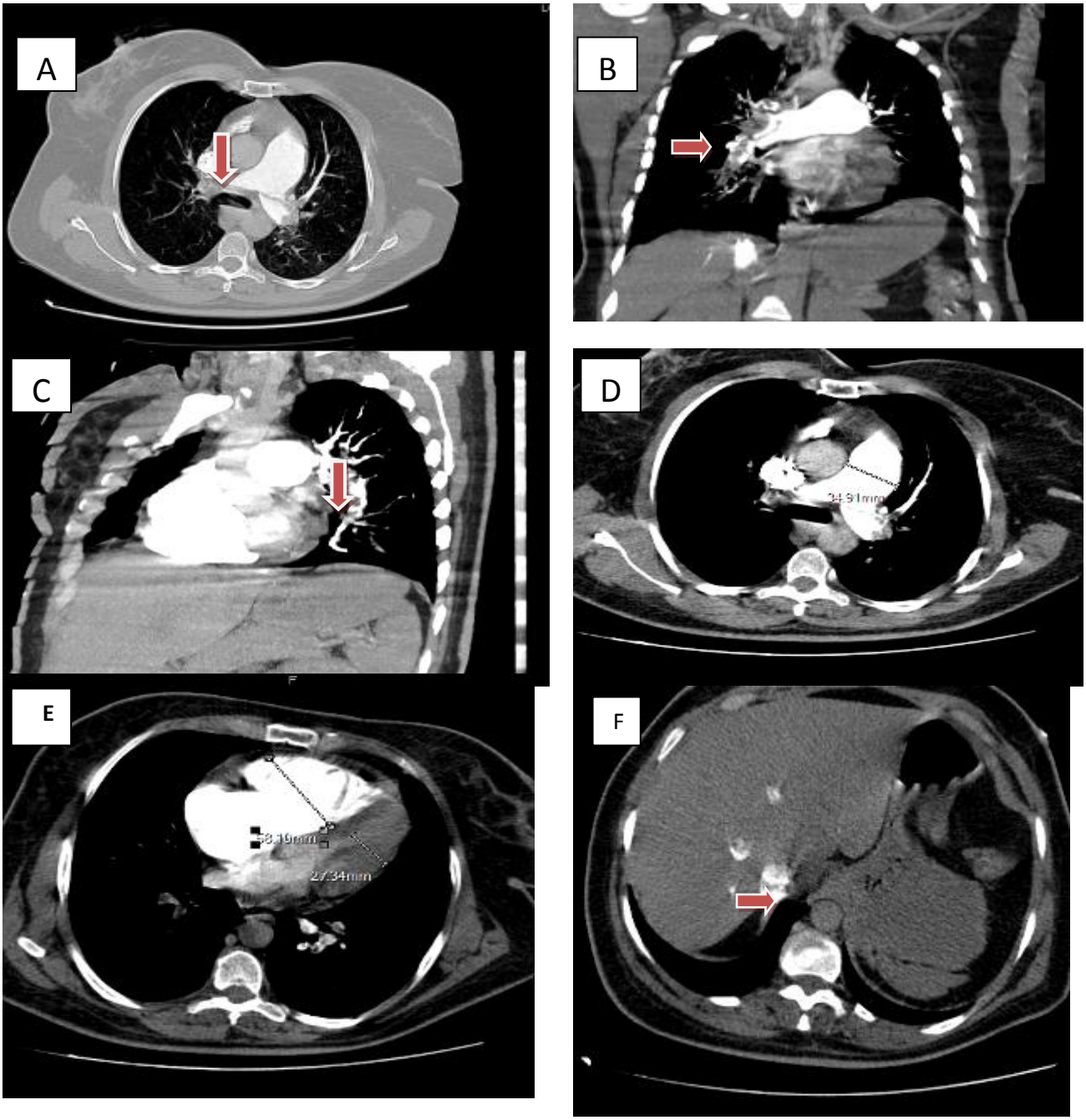

Fig (4): pulmonary embolism (A) Axial image. (B) Coronal image. (C) Sagittal image. (D) PA diameter. (E) RT to LT ventricular ratio. (F) Reflux of the contrast inside IVC.

DISCUSSION

Acute PE is a disease with a variable prognosis. In recent years, many attempts have been made to stratify patients according to their risk of death due to PE. From the results of large retrospective registries and randomized trials of thrombolytic, clinical presentation is considered the most powerful predictor of death due to PE. However, there have been attempts to further risk-stratify patients with imaging. In several small prospective studies, right-sides heart strain, as demonstrated with echocardiography has been shown to be predictive of death in acute PE [7].

Patients with pulmonary embolism and right ventricular dysfunction often present with a spectrum of symptoms, and treatment is based on the presentation [8].

Risk stratification is important in patients with acute PE to identify those at low, intermediate or high risk for adverse outcomes. Low-risk patients are candidates for an early discharge or even home treatment, whereas intermediate or high risk patients should be admitted to the hospital and considered for an upgrade in treatment [9].

This study was conducted on twenty one (21) patients with clinical suspicion of PE due to persistent non diagnosed acute chest pain referred to Radiology Department at Ain Shams University Hospital, for evaluation by MSCT pulmonary angiography.

The age of patients ranged from 22 to 83 years old with 56.29 + 18.9 years mean age. The female patients representing the majority of our cases represented by 13 patient (61.9% of the cases).

After examination by MSCT pulmonary angiography our study revealed:

Our study agreed with ***Perrier et al.*** [10], **Van *Belle et al.*** [11] **and *Venkatesh et al.*** [12] whose studies showed predominant female patients with 60%, 57 % and 67% incidence respectively.

In our study, the clinical presentation of patients was as follows: 16 patient were presented by dyspnea representing 76.2%, 13 patient had acute chest pain representing 61.9%, 2 patients had tachypnea representing 9.5%, 5 patients were presented by tachycardia representing 23.8 % and none of the patients was presented by hemoptysis.

The reported result in our study agreed with ***Crichlow et al.***[13]whose study showed that the most common presenting signs and symptoms were shortness of breath (77%), followed by chest pain (74.3%). Also, the reported result in our study agreed with ***Tambe et al.*** [14] study that showed that the most common clinical symptoms were sudden and/or unexplained chest pain, dyspnea, malaise, syncope or shortness of breath .After examination by MSCT pulmonary angiography, the images had shown that the thrombus was found within the pulmonary arteries as follow: 12 patient had shown thrombus at level of main pulmonary artery **(**12 of 21) representing 52.4 %, 13 patients had shown the thrombus within the lobar pulmonary arteries (13 of 21) representing 61.9% and 8 patients had shown thrombus within segmental pulmonary arteries (8 of 21) representing 38.1%. The reported results of anatomical distribution of the pulmonary emboli in our study are closely related to the reported results of ***Comert et al.***[15] in which 50 patients with suspected PE were included in their study & CTPA had shown PE in 30 patients and the thrombus was detected as follow: 12 thrombus at right or left main pulmonary arteries (24 %), 23 (46 %) thrombus at segmental level.

Calculating the clot burden score is important in determination of the degree of vascular obstruction which helps in stratification of patient risk and identification of those who would benefit from more aggressive treatment. The clot burden score also enables the effects of treatment to be monitored non-invasively by subsequent imaging studies [5].

Our study showed that the mean OI was 28.6 % compared to 35 % reported by ***Attia et al.*** [16] whose study included 70 patient. That difference might be due to the small number of our study group, however it is almost equal to that reported by ***Qanadli et al.*** [5] which was 29 % in a study including 158 patient.

In this work there was a linear correlation between the OI and RVD ratio as assessed by MDCT pulmonary angiography. The mean OI was higher in patients with RVD, than patients without. This was also reported in the study of ***Rodrigues et al.*** [17] . Who found a linear correlation between Qanadli Score and RVD parameters on CT angiography.

The cut-off point for the OI that predicted the presence of RVD (with a significant sensitivity and specificity) in our study was 37.5 % which means that most patients with OI above 37.5% had RVD. These results were comparable to those reported by ***Qanadli et al.*** [5], ***Attia et al.*** [16] and ***Rodrigues et al.*** [17] who reported cut off point of OI values of 40 %, 45% & 43 % respectively. Our study results are slightly low compared to those other studies likely attributed to our small study group in comparison to larger groups in other studies. However the results of our study further support

the use of MDCT pulmonary angiography as a single test for both diagnosis and risk stratification in patients presented with acute PE.

CONCLUSIONS

From our study we concluded that:

There is a strong association between OI and RVD so, the assessment of pulmonary clot burden index and score using an objective and reproducible MDCT score has a considerable clinical and imaging impact, enabling accurate diagnosis, risk stratification and the selection of patients for more aggressive treatment.

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