ROLE OF MULTISLICE COMPUTED TOMOGRAPHY IN EVALUATION OF PULMONARY HYPERTENSION SECONDARY TO LUNG DISEASES.

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ABSTRACT

Background: pulmonary arterial hypertension (PAH) is a progressive disorder of the pulmonary vasculature that leads to right sided heart failure and even death if not discovered and properly treated. PAH due to lung disease is usually modest (mean PAP<35) , rarely sever in less than 1%.
Aim: to evaluate the ability of multislice computed tomography to detect pulmonary arterial hypertension in patients with pulmonary diseases.
Patients and Methods: This study was carried out at chest and radiology departments Zagazig university hospitals during the period from March 2014 to August 2014. Twenty seven with echo diagnosis of elevated pulmonary artery pressure due to known chest diseases were subjected to radiological examinations including plain X-ray, echocardiography and multislice computed tomography (MSCT), the main PA diameter to be measured at point of bifurcation at right angle to its long axis and just lateral to the ascending aorta.
Results: Twenty seven patients included in the study, they were 17 male and 10 female with age ranged from 30 to 72 years. The diameter of the main pulmonary artery (PA) was the first radiological sign to be assessed. Twenty five (25, 92.5%) patients have a ratio between the main pulmonary artery diameter and the ascending aorta diameter (PA / AO ratio) more than (1: 1) which was related to the systolic pulmonary artery pressure reported by Echocardiography.
Conclusion: MSCT can be a reliable tool for detection of pulmonary hypertension secondary to pulmonary diseases.
Keywords: MSCT; pulmonary hypertension

INTRODUCTION

Pulmonary hypertension is a life-threatening chronic disorder of the pulmonary circulation. It is defined by a mean pulmonary arterial pressure over 25 mm Hg at rest with normal pulmonary capillary wedge pressure (PCWP) < 15 mm Hg (1).

Pulmonary hypertension is characterized by progressive involvement of the pulmonary vessels that leads to increased vascular resistance and consequently to right ventricular failure (2).

WHO classification pulmonary hypertension can be categorized as: pulmonary arterial hypertension, pulmonary venous hypertension, Pulmonary hypertension associated with lung diseases and / or hypoxemia ,chronic thrombo-embolic pulmonary hypertension and pulmonary hypertension from other causes (3).

Pulmonary hypertension associated with lung diseases (hypoxic) is common with chronic obstructive pulmonary disease (COPD), interstitial lung disease (ILD) , sleep disordered breathing , alveolar hypoventilation, chronic exposure to high altitude and developmental lung abnormalities (4) .

In cases of suspected pulmonary hypertension, imaging methods can confirm the diagnosis, suggest a cause, help choose the most appropriate treatment, and monitor the response to treatment. Although invasive hemodynamic assessment with right heart catheterization is requested to confirm the definite diagnosis of PH showing a resting mean pulmonary artery pressure (mPAP) of ≥ 25 mmHg and a normal pulmonary capillary wedge pressure (PCWP) of ≤ 15 mmHg, echocardiography is an important tool in the management of patients with suspected PH. The European Society of Cardiology and the European Respiratory Society (ESC-ERS) guidelines specify its role, essentially in the screening, proposing criteria for estimating the presence of PH mainly based on tricuspid

regurgitation peak velocity and systolic pulmonary artery pressure (sPAP) (2, 16).

The development of multi - detector CT has opened a wide range of recent applications. It has allowed the development of imaging technique for vascular imaging (5).

MDCT technique allows increase in gantry speed and acquisition of contiguous sections with a section thickness of (1 mm) or less throughout the thorax, with an enhancement on all acquired sections, and the narrow collimation increases spatial resolution and reduces partial volume averaging (6).

The diameter of the main PA diameter should be measured at the point of its bifurcation at right angle to its long axis and just lateral to the ascending aorta , it is preferable to compare the main PA diameter and the ascending aorta and calculate the ratio between them (PA/ AO) ratio (2)

An enlargement of the main pulmonary artery greater than 29 mm may be seen on the CT scan . This finding has a sensitivity of 87% and a specificity of 89% for the diagnosis of PH. The specificity up to 100% when in addition to a diameter equal to or greater than 29 mm, is a segmental artery – bronchus ratio greater than 1:1 in most lung lobes (7)

PATIENTS AND METHODS

This study was carried out at chest and radiology departments, Zagazig university hospitals during the period from March 2014 to August 2014.

Twenty seven patients were recruited from chest department ward after confirmation of the diagnosis of chest diseases and the presence of PAH by recent echocardiography (less than 3 months before enrollment into the study). Patients were enrolled to the study after being clinically stable to exclude the indication of hospital admission as a cause of elevation of PAP (e.g. pneumonia AECOPD). MSCT was interpreted by a qualified radiologist who was blinded about both chest disease diagnosis and the echocardiography finding.

The following was done for all patients.

Clinical assessment

All patients were subjected to:

-Through medical history.

-General examination including general and local (chest) examination.

-Electrocardiogram(ECG) All patients were examined by ECG.

- Pulmonary function test and arterial blood gases.

-Radiological examination and imaging:

A- Plain X-ray:

All patients were examined by plain x-ray to the chest of in postro-anterior position. X-rays were performed using SIEMENS Multix Swing 500 mm at Zagazig university hospitals.

B- Transthoracic Doppler-echocardiography (TTE).

All patients were examined by echocardiography for assessment of pulmonary artery systolic pressure and other echocardiographic variables that might raise or reinforce suspicion of PH including: an increased velocity of pulmonary valve regurgitation, short acceleration time of RV ejection into the PA. Increased dimensions of right heart chambers, abnormal shape and function of the interventricular septum, increased RV wall thickness, and dilated main PA. Echocardiography was used for diagnosis of pulmonary hypertension and showed good accuracy especially with the recent advanced scoring systems, combining various echo-derived measurements of PAH e.g. tricuspid annular plane systolic excursion (TAPSE) might more accurately identify and assess progress of PHT and can reduce the need for invasive assessments especially when it is not required to initiate or monitor treatment of PHT. TTE also allows a differential diagnosis of the possible causes of pulmonary hypertension. TTE can recognize valvular diseases and myocardial diseases responsible for post-capillary PH, and congenital heart diseases with systemic-to-pulmonary shunts. The venous injection of agitated saline can help to identify patent foramen ovale or atrial septal defects.

C-Computed Tomography

CT studies were performed using TOSHIBA ACTIVION 16 multislice CT system and GE BRIGHTSPEED 4 multislice device .

Axial CT cuts were performed on all 30 cases from the level of the manubrium sterni to the

level of the diaphragm in both lung and mediastinal window ; 5 mm slice thickness with exposure factors of 120 kV and 150-200 mAs. , CT scan with or without contrast injection was done . The used contrast media was (urografin 76%) in a dose of 40-80 ml, administered as a bolus injection.

Patient preparation:

No special preparation was needed except fasting for about 4-6 hours before examination.

Patient position :

All patients were examined supine and immobilized in a comfortable position (2).

RESULTS

The present study included 27 patients, 17 males and 10 females, with male: female ratio 1.7:1. The patients ages ranged from 30 to 72 years, with mean age of 43 + 16.7 years. It was observed that the most frequently affected age group was [45-<60] which represents 55.5% of the studied patients (**table 1**).

The number and percentage of pulmonary diseases, pulmonary artery diameter and mean PAP among studied patients according to the type of chest disease was represented in (**table 2**). Pulmonary diseases included in the study were; COPD (7 patients), bronchiactasis (5 patients), interstitial pulmonary fibrosis {IPF} (5 patients), bronchial asthma (2 patients), obesity hypoventilation syndrome {OHS} (3 patients), connective tissue disease related diseases {CTRD} (2 patients), sarcoidosis (1 patient), and sleep disordered breathing {SDB} (2 patients) (**table 2**).

The most frequent symptoms and signs were dyspnea, cough, fatigue, heamoptysis, day time sleepiness, loss of appetite, fever, lower limb edema and clubbing (**table 3**).

The main PA diameter was measured at the point of its bifurcation at right angle to its long axis and just lateral to the ascending aorta (**table 4**).

Among the studied cases, 25 patients have a ratio between the main pulmonary artery size and the ascending aorta size (PA / AO ratio) more than (1: 1) (**table 5**).

Table (1): Shows the age groups, percentage of each age group among both sexes .

Age	Male		Female		Total	
	No.	%	No.	%	No.	%
30-<45	5	29%	3	30%	8	29.7%
45-<60	10	59%	5	50%	15	55.5%
60-<75	2	12%	2	20%	4	14.8%
Total	17	100%	10	100%	27	100%

Table (2): Shows the number and percentage of pulmonary diseases, pulmonary artery diameter and mean PAP among studied patients:

Pulmonary disease	No. 30	%	Pulmonary artery diameter Mean ± SD	Mean pulmonary artery pressure
COPD	7	25.9%	2.9 - 3.9 cm	34 ± 6.5
Bronchiactasis	5	18.5%	2.9 - 3.9 cm	35 ± 4.6
IPF	5	18.5%	3.9 - 4.9 cm	40 ± 5.6
Bronchial asthma	2	7.4%	≥2.9 cm - 3.0 cm	25 ± 1.2
Obesity hypoventilation syndrome	3	11.1 %	3.9 - 4.9 cm	38 ± 5.6
Sarcoidosis	1	3.7%	2.9 - 3.9 cm	36 ± 2.8
Connective tissue disease related ILD	2	7.4%	3.9 - 4.9 cm	37 ± 3.6
Obstructive Sleep Apnea	2	7.4%	3.9 - 4.9 cm	39 ± 4.2
Total	27	100%		

Table (3): The frequency of pulmonary symptoms and signs among studied patients.

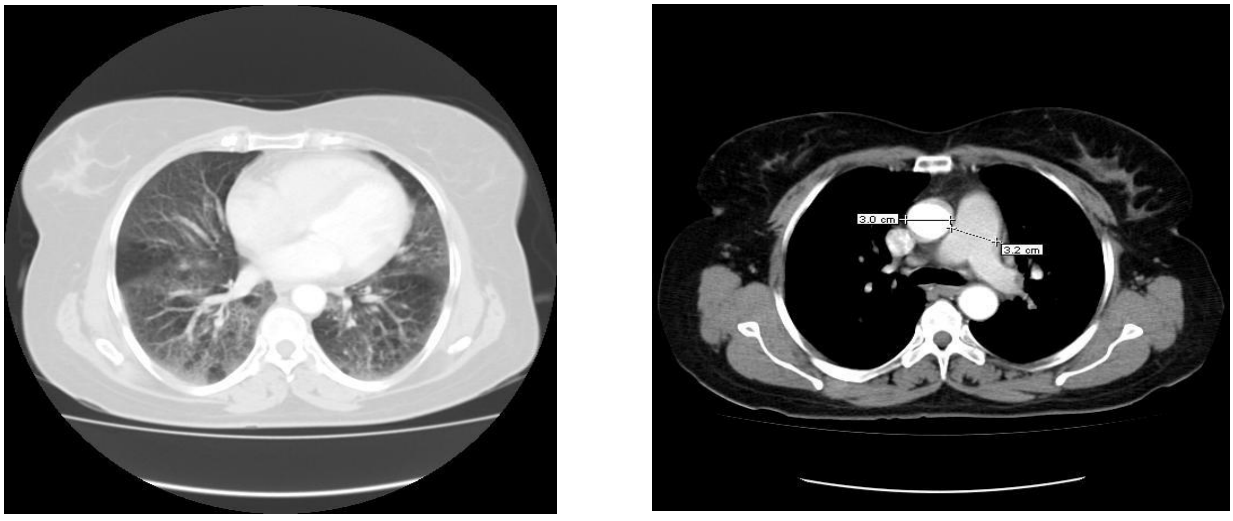
Symptoms and Signs	No.	%
Dyspnea	27	100%
Cough	21	77.7%
Fatigue	21	77.7%
Lower limb edema	15	55.5%
Clubbing	11	40.7%
Hemoptysis	4	14.8%
Day time sleepiness	3	11.1 %
Loss of appetite	2	7.4%
Fever	2	7.4%

Table (4): The number and the percentage of main pulmonary artery diameters in the studied patients.

Diameter of Main pulmonary artery	No.	%
≤ 2.9 cm	2	7.4%
2.9 < 3.9 cm	13	48.1%
3.9 < 4.9 cm	12	44.4%
Total	27	100%

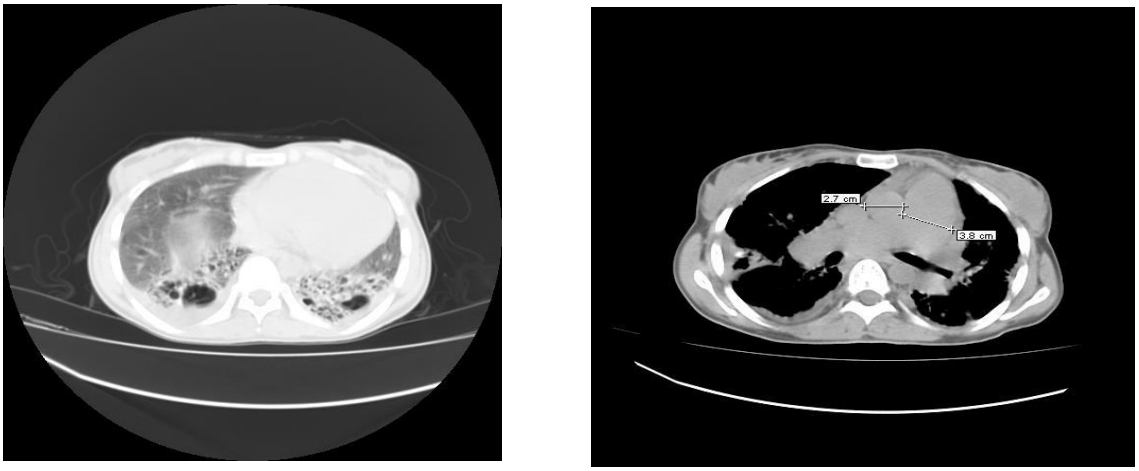
Table (5): Shows the (PA / AO ratio) distribution among studied patients.

PA / AO ratio	No.	%
> 1 : 1	25	92.5 %
≤ 1 : 1	2	7.4 %
Total	27	100%



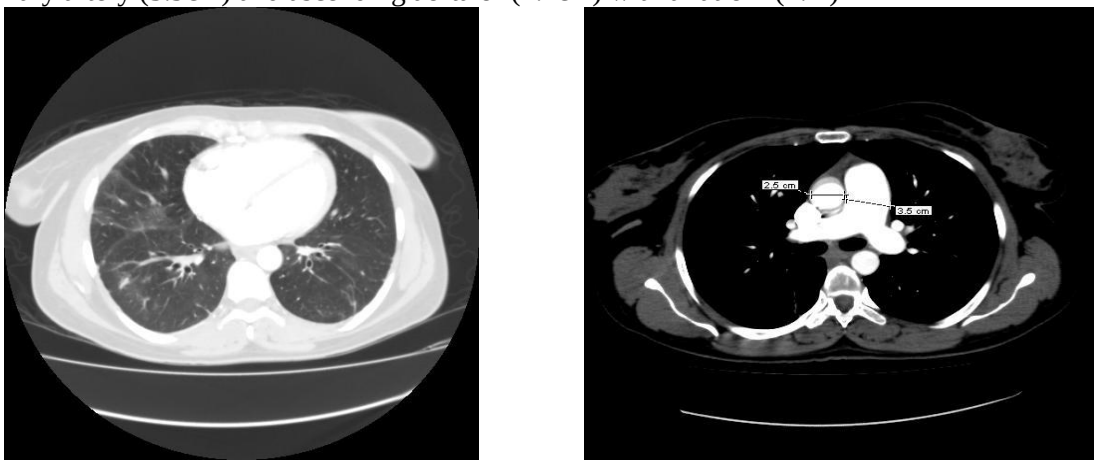
(A) (B)

Figure (1) : MSCT of a 56 years old female, (A): Bilateral sub pleural reticulations and ground glass opacities most pronounced in lung bases (B). Mild dilated main pulmonary artery (3.2 cm) and ascending aorta of (3 cm) with a ratio > (1 : 1)



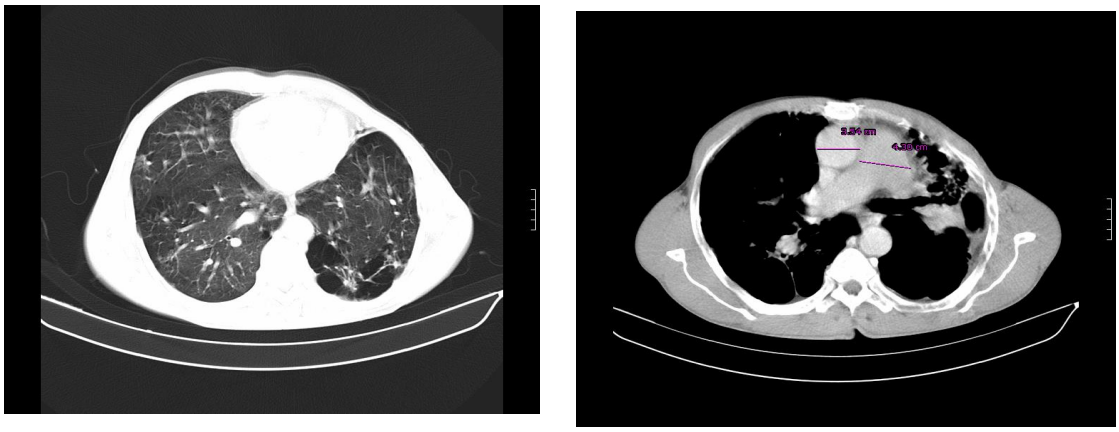
(A) (B)

Figure (2) : MSCT of a 49 years old, (A): Bilateral bronchiectasis is demonstrated more pronounced at lung bases, in addition, multiple linear fibrotic strands are noted with costal pleural thickening. (B) Dilated main pulmonary artery (3.9cm) and ascending aorta of (2.7cm) with a ratio > (1: 1)



(A) (B)

Figure (3) : MSCT of a 38 years old female, (A) Patchy bilateral ground-glass density lesions (B) Dilated main pulmonary artery (3.5cm) and Ascending aorta of (2.5cm) with a ratio > (1 : 1)



(A) (B)

Figure (4) : MSCT of a 62 years old male patient presented with sever dyspnea, (A): multiple fibrotic strands, nodularity and air filled cavities (B) Dilated main pulmonary artery (4.3 cm) and Ascending aorta of (3.5 cm) with a ratio > (1: 1)

DISCUSSION

Pulmonary hypertension associated with lung diseases (hypoxic) is common with chronic obstructive pulmonary disease (COPD) , interstitial Lung disease (ILD) , sleep disordered breathing , alveolar hypoventilation, chronic exposure to high altitude and developmental lung abnormalities (4) .

In 90% of PAH patients, the chest radiograph is abnormal at the time of diagnosis, however a normal chest radiograph may also be seen. Chest radiographic findings of PH include main and hilar pulmonary arterial dilatation with attenuation of peripheral pulmonary vascular markings (pruning or loss). cardiomegaly with predominant right ventricular (RV) enlargement may be present (9).

The present study aimed for evaluation of the ability of MDCT to detect PAH id addition to its value in providing thin-section images of the lung parenchyma for detection of abnormalities in most common cases of secondary pulmonary hypertension (10).

Echocardiography was accurately used to diagnose pulmonary hypertension especially with the recent advances in the field. In the future, a scoring system using combination of various echo-derived measurements may be more accurate to identify and assess progress of PAH and reduce the need for invasive assessments unless required to initiate or monitor treatment of PAH (2, 17).

It was better in the present study to validate the finding of MDCT by the most reliable method for evaluation of PAH (right heart catheter RHC), but several factors did not motivate the referral to RHC, including: unavailability of RHC, lack of expertise, and most patient were mild to moderate PAH by echo. Another factor was that; the study mainly concerned with screening purpose rather than initiation or monitoring treatment of PAH.

among the studied patients subjected to MDCT examination, 17 patients were males and 10 patients were females (ratio 1.7:1). These results were not in agreement with **Joshi,** (11) who stated that male are affected more often than female, at a ratio about 1.5:1. But disagree with and **David et al,** who reported female predominance in most causes of PAH (1.9 : 1) this disagreement could be due to the nature of our patient which was mainly chest patients and the majority were COPD, ILD ,OSA and bronchiactasis which are more common in males. And actually the precise prevalence of PAH among these disease still largely unknown (16).

The present study showed that, age range between 30 and 73 years mean (43 ± 16.7) and 55.5% of the patients aged between 45 and 60 years, 29.7% of the patients between 30 and 45 years old, and 14.8% of patients over the age of 60 years. These results were compatible with those of **Joshi,** (11) who stated that most of patients are between the ages of 21 and 71 years at the time of presentation. And most of the cases are around fifties especially in COPD and ILD patients, he also mentioned that the mean age at diagnosis is 41±45 years. Also **David et al,** who stated that.tha mean age of PAH patients is 50 with quarter of patient older than 60 underlining the possibility of PAH development at any age (16).

Our findings showed that bronchial asthma patients showed the lowest PAP and PA diameter (25 ± 1.2, < 29 mm respectively **table 2**) followed by COPD (34 ± 6.5, 29-39 mm respectively **table 2**), bronchiactasis (35 ± 4.6, 29-39mm respectively) and sarcoidosis while the highest PAP and PA diameter were showed in ILD patients (40 ± 5.6, 49-59 mm respectively **table 2**). While OSA and OHS were (39 ± 4.2, 39-49 mm, 38 ± 5.6 , 39-49 respectively **table 2**). Since hypoxemia is the main cause of PAH in most chest disease the findings seems accepted where hypoxemia occurs more early and more profound in IPF than in other chest disease e.g. in COPD hypoxemia does not occurs except late in the disease course and occurs only in advanced sarcoidosis. While in asthma hypoxemia only occur in the sever attacks due to the intermittent nature of the disease, in the present study only one of the 2 asthmatics showed PA diameter > 1/1 while both patients showed elevated systolic PA pressure by echocardiography at enrollment in the study, this could be due to the mild elevation in their PAP and the nature of the disease as an

isolated airway disease without parenchymal involvement and so the reflection on the pulmonary dilation is not marked, unlike other diseases as COPD and ILD (table 2),

In our study dyspnea especially with exertion found to be the most common clinical finding in all patients, dyspnea either at rest or with exertion, was evident in 100% of patients fatigue and cough were also very common found in 21 cases. These results were in agreement with **Trenton and Steven, 2001** (13) whom stated that the most common symptom of PH was exertional dyspnea, then fatigue which reflect an inability to increase cardiac output during activity.

In our study, among the 27 patients, the main PA diameter in 25 cases measured at point of bifurcation at right angle to its long axis and just lateral to the ascending aorta is greater than or equal to 29 mm. Also our findings showed that the ratio between segmental artery and bronchus was greater than 1:1 in most lung lobes as shown by MDCT in most of the cases examined. These results were compatible with those of **Devaraj and Hansell, 2009** (7) and **Frazier et al., 2000** (14) whom stated that when main PA is greater than or equal to 29 mm has an indication of 87% sensitivity and 89% specificity for PH. The specificity up to 100% when in addition to a diameter equal to or greater than 29 mm, is a segmental artery – bronchus ratio greater than 1:1 in most lung lobes.

The present study revealed that 25 out of 27 patients have a ratio between the main pulmonary artery size and the ascending aorta size (PA / AO ratio) more than (1: 1), and in 2 patients (PA / AO ratio) equal (1:1). These results were compatible with those of **Ng et al., 1999** (15) who stated that if the ratio between main pulmonary artery and ascending aorta (PA / AO) is greater than (1:1), it is likely to be PAH.

The present study demonstrated that, it could be possible to use MDCT both for diagnosis of the primary lung disease and for evaluation of the pulmonary artery diameter in one step, and also as reliable screening tool for the presence of PAH during routine CT examination for diagnosis of pulmonary disorders.

Conclusion:

As a noninvasive test, MDCT has the potential to provide the first pointer toward the diagnosis of PAH; MDCT offers anatomic information about the size of the pulmonary arterial tree and signs of right ventricular dysfunction beside its ability to provide thin-section images of the lung parenchyma.

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