Assessment of the role of computed tomography versus echocardiography in pulmonary hypertension

Ahmed Z.E. Abdelhafiz[a], Khaled A. Al Khashab[b], Assem F. Elessawy[c], Radwa A. Elhefny[c], Fatmaalzahraa S. Abdalrazik[d]

Background The era of diagnosing pulmonary arterial hypertension is rapidly evolving. There are changes in the definition, screening, diagnostic modalities, and disease staging.

Aim This study aims to assess pulmonary hypertension using computed tomography (CT) and echocardiography.

Design This is a cross-sectional study.

Participants and methods This study included 30 cases diagnosed with pulmonary artery hypertension according to the inclusion and exclusion criteria. All patients were subjected to a careful assessment of history, a skillful clinical examination, and investigations: (a) complete blood picture, liver kidney functions, bleeding profile, and arterial blood gases. (b) Spirometry. (c) Echocardiogram. (d) CT chest.

Results The correlation between the ratio of main pulmonary artery and aorta to other study parameters was statistically significant. There was a negative statistically significant correlation between the mP/Ao ratio and oxygen saturation (P=0.001); however, we found a positive significant correlation between the mP/Ao ratio and ejection fraction (P=0.006), systolic pulmonary artery pressure (P<0.0001), and mean pulmonary artery pressure (P<0.0001). In contrast, the correlation was nonsignificant when the mP/Ao ratio was compared with other parameters (P>0.05), and a nonsignificant correlation was also found between systolic pulmonary artery pressure and duration of dyspnea (P>0.05).

Conclusion This study has shown that combining CT and echocardiography in the diagnosis of pulmonary hypertension can be a reliable technique to measure mean pulmonary artery pressure than if any of both tests done separately.

Egypt J Bronchol 2019 13:743–746

Egyptian Journal of Bronchology 2019 13:743–746

Keywords: chest computed tomography, echocardiography, pulmonary hypertension

[a]Chest Diseases Hospitals, Egyptian Ministry of Health, Cairo, Egypt, [b]Department of Cardiovascular Diseases, [c]Department of Chest Medicine, Faculty of Medicine, Fayoum University, Fayoum, [d]Department of Chest Medicine, Faculty of Medicine, Helwan University, Cairo, Egypt

Correspondence to Fatmaalzahraa S. Abdalrazik, MD, Department of Chest Medicine, Faculty of Medicine, Helwan University, Ain Helwan, Helwan, Cairo 11795, Egypt. Tel: +20 122 722 3565;
e-mails: fatemaalzahraa.saad@med.helwan.edu.eg, fatemaalzhraa_saad@yahoo.com

Received: 18 June 2019 **Accepted:** 10 September 2019
Published: 21 January 2020

Introduction

Pulmonary hypertension (PH) is considered when the mean pulmonary artery pressure (mPAP) is more than 25 mmHg while measured at rest, estimated by right cardiac catheterization. Pulmonary arterial hypertension is diagnosed in patients who have pre-capillary PH, pulmonary vascular resistance more than three Wood units, and end-expiratory pulmonary artery wedge pressure less than 15 mmHg [1].

Irrespective of its etiology, the diagnosis of pulmonary arterial hypertension is crucial because of its association with bad prognostic predictors [2]. Catheterization of the right side of the heart is considered the gold standard modality in diagnosing PH, despite being an invasive technique with many drawbacks [3]. Doppler echocardiography is usually considered a noninvasive, commonly used measure that assesses systolic pulmonary artery pressure (sPAP). This technique could be inexact, especially in interstitial lung disease [4]. Computed tomography (CT) is frequently performed for patients with predicted PH. The structures of the pulmonary vessels and heart with CT were studied accurately as an indicator of elevated mPAP [5].

This study was designed to evaluate the feasibility of CT in diagnosing PH, and comparing CT sensitivity to echocardiography and If Both tests combined together in diagnosing PH.

Participants and methods

Study design

This study is a prospective research that included 30 in-patients from the Chest Department in Fayoum University Hospital and diagnosed with PH secondary to chest disease from September 2015 to February 2016.

Ethics approval was obtained from the Ethical Committee of the Faculty of Medicine, Fayoum University, and consent was obtained from the patients' relatives.

 DOI: 10.4103/ejb.ejb_56_19

Patients

All study cases were subjected to detailed assessment of medical history, full clinical examination, routine chemical and hematological blood tests, spirometry including forced vital capacity – forced expiratory volume in the 1 s – forced expiratory volume in the 1 s/forced vital capacity ratio, pulse oximetry, echocardiography, and CT chest.

Inclusion criteria

PH secondary to primary pulmonary disease.

A patient is considered to have PH when the pulmonary artery pressure by echocardiography is more than 25 mmHg as measured by the Bernoulli equation [6].

Analytical method

Echocardiography

Transthoracic echo-Doppler was done using the Toshiba Apolio 300 Ultrasound System (Cannon Medical Systems Corporation, Ōtawara, Japan). Two-dimensional images were taken. The pericardium, left-side chamber, and right-side chamber sizes, valves, and function were assessed. The right ventricular size and function were measured. Tricuspid regurgitation was assessed. Systolic pressure of the right ventricle was measured using the modified Bernoulli equation (equals sPAP in case of absence of outflow obstruction of the right ventricle) [4]. Pulmonary artery systolic pressure (PASP)=4 (tricuspid jet velocity squared)+right atrial pressure.

Computed tomography chest imaging

CT chest was performed using the Toshiba Aquilion Prime 160 slice MDCT scanner (Cannon Medical Systems Corporation). All candidates were examined while lying supine, holding their breath in deep inspiration. Thirty patients underwent high-resolution CT with an intravenous contrast injection. The widest short-axis dimension of the main pulmonary artery on axial cuts at the level of the main pulmonary artery bifurcation through the mediastinal cuts of CT. The main pulmonary artery cross-sectional area was also measured. The thoracic vertebra and the ascending aorta were measured at the widest short-axis diameters in the same cut used to evaluate the main pulmonary artery. The mid anteroposterior diameter of the vertebra is rarely affected by osteophytes; thus, it was chosen as a suitable area to be evaluated.

Statistical methods

We used mean±SD, median and range, or frequencies and percentages to describe data. Pearson's moment correlation equation was used for linear relations. *P* values less than 0.05 were considered to be statistically significant. All statistical calculations were carried out using the computer program SPSS (SPSS Inc., Chicago, Illinois, USA) release 15 for Microsoft Windows (2006).

Results

This study included 30 patients, six males and 24 females; their age ranged from 13 to 78 years (mean ±SD 46±19.2). Twenty-six (86.7%) patients were nonsmokers and four were smokers (Table 1). 6.7% of these patients had obstructive lung disease and 93.3% had restrictive lung disease (most of our candidates were diagnosed with interstitial lung) (Table 2). The mean blood oxygen saturation of the 30 cases was 90.57±7.67, ranging from 68 to 99 (Table 3).

By doppler echocardiography, the mean ejection fraction was 67.10±6.13, ranging from 53 to 85, the mean sPAP was 54.23±19.51, ranging from 38 to 128, and the mPAP was 35.39±11.99, ranging from 25.2 to 80.1 (Table 4).

Table 1 Descriptive characteristics of all study cases

Variables	Mean±SD (range)
Age (years)	46±19.2 (13–78)
Sex [*N* (%)]	
Male	6 (20)
Female	24 (80)
Smoking	
Nonsmokers	26 (86.7)
Smokers	4 (13.3)

Table 2 Degree of airway limitation among study cases according to pulmonary function tests

Variables	*N* (%)
Obstructive	2 (6.7)
Restrictive	28 (93.3)

Table 3 Oxygen saturation among the studied patients

Variable	Mean±SD	Range
Oxygen saturation	90.57±7.67	68–99

Table 4 Echocardiographic and computed tomography findings of all study participants

Variables	Mean±SD	Range
Ejection fraction	67.10±6.13	53–85
Systolic pulmonary artery pressure	54.23±19.51	38–128
Mean pulmonary artery pressure	35.39±11.99	25.2–80.1
Main pulmonary artery/aorta ratio	1.19±0.29	0.73–2.10

When the same population was assessed by CT chest with contrast, we found that the mean main pulmonary artery and aorta main pulmonary artery/aorta ratio (mPa/Ao) ratio was 1.19±0.29, ranging from 0.73 to 2.10, 23.3% of cases had lymphadenopathy, 10% showed hyperinflated chest with emphysema, 66.7% had the ground glass pattern, 66.7% had bronchiectasis, 23.3% had the reticulonodular pattern, 60% had honey combing, 53.3% had a prominent pulmonary artery, and 16.7% were found to have pericardial effusion (Table 4).

Agreement between the mPa/Ao ratio and sPAP was found to be significant. The mPa/Ao ratio and sPAP agreed that 21/30 (70%) of the participants had PH and 3/30 (10%) of the patients did not have PH, with total agreement of 24/30 (80%), Cohen's κ=0.392 and P=0.019 (Table 5).

In this study, we found a significant correlation between the mPa/Ao ratio and the study parameters: we found a negative correlation of statistical significance between the mP/Ao ratio and oxygen saturation (P=0.001), whereas there was a positive correlation of statistical significance between the mP/Ao ratio and ejection fraction (P=0.006), sPAP (P<0.0001), and mPAP (P<0.0001). However, our results showed that the correlation of the mP/Ao ratio with the other variables (P>0.05), and the correlation between sPAP and duration of dyspnea (P>0.05) were not different (Table 6).

Devaraj *et al.* [7] illustrated in their study that the diameter of the ascending aorta to the cross-sectional area of the main pulmonary artery is correlated equally with mPAP. Also, they concluded that combining both CT and echocardiography in PH can represent mPAP than each test separately.

Tan *et al.* [8] reported that the CT-determined mean pulmonary artery diameter plays an excellent diagnostic role in detecting PH in advanced lung disease patients.

A study carried out in 2014 by Lick *et al.* [9] included 127 patients who underwent computed tomography pulmonary angiography (CTPA) and echocardiography within 48 h of each other. They found that left atrial sizes in CTPA and Doppler echocardiography are strongly correlated. Also, found that ration of mPa/Ao measured by CTPA in patients with increased pulmonary artery pressure. These results were markedly different compared with those of patients with normal pulmonary artery pressure. The researchers found that left atrial size measured by CTPA and that measured by echocardiography are strongly correlated.

Li *et al.* [10] recruited 85 patients with chronic chest diseases and performed both CT chest and right heart catheterization (RHC). The mPAP, PASP, and pulmonary arterial diastolic pressure were assessed

Table 5 Agreement between the main pulmonary artery/aorta ratio and systolic pulmonary artery pressure

	Main pulmonary artery/aorta ratio		Cohen's κ	*P* value
	Pulmonary hypertension	Normal		
Systolic pulmonary artery pressure				
Pulmonary hypertension	21	5	**0.392**	**0.019***
Normal	1	3		

Bold and (*) means this value of statistical significance.

Table 6 Correlation between main pulmonary artery/aorta ratio, systolic pulmonary artery pressure ratio, and study parameters

	Main pulmonary artery/aorta ratio	
	r	*P* value
Age	0.036	0.849
Respiratory rate	0.062	0.745
Heart rate	0.321	0.084
Forced vital capacity	–0.066	0.732
Forced expiratory volume in the 1 s	–0.168	0.374
Forced expiratory volume in the 1 s/forced vital capacity ratio	–0.073	0.702
Oxygen saturation	–0.576	0.001*
Ejection fraction	0.490	0.006*
Systolic pulmonary artery pressure	0.862	<0.0001*
Mean pulmonary artery pressure	0.848	<0.0001*
Systolic pulmonary artery pressure (duration of dyspnea)	–0.133	0.485

*Means theses values of statistical significance.

during RHC. Diameters of the main pulmonary artery, descending aorta, and ascending aorta, Cobb angle, diameters of left ventricle, and diameters of right ventricle, and diameters of left ventricle were estimated in CT. The mean values of CT-expected measures and RHC measures were statistically nondifferent.

In contrast to our finding, Iyer *et al.* [11], carried out a study that included 60 cases. They were evaluated by CT chest and echocardiography. The study concluded that the CT scan is more accurate than echocardiography in diagnosing resting pulmonary artery pressure in patients with severe chronic obstructive pulmonary disease (COPD).

A meta-analysis study that included 29 researches collected by Janda *et al.* [12] found that Doppler echocardiography is a reliable, noninvasive technique for assessing PASP, but because of some limitations, RHC should be performed during diagnosis and follow-up of PH.

The limitations of this study were its cross-sectional nature and the fact that the study population was not homogenous with underlying lung disease. Also, despite almost equal numbers of candidates with interstitial lung disease and pulmonary vascular disease, special conditions, such as emphysema, were underrepresented.

Although noninvasive tools, such as echocardiography, help to assess PASP, this technique is usually problematic in COPD patients because of hyperinflation and difficult acoustic windows. It is important to note that all measurements are performed at rest.

The study authors recommend further investigation to compare the combined measurement of CT and echocardiography with RHC in measuring PASP.

Conclusion

This study has proven the synergistic effect of combining of CT and echocardiography in PH together is a more reliable technique in measuring mPAP than if any of both tests done alone.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Hoeper MM, Pletz MW, Golpon H, Welte T. Prognostic value of blood gas analyses in patients with idiopathic pulmonary arterial hypertension. *Eur Respir J* 2007; **29**:944–950.

2 Coghlan JG, Handler C. Connective tissue associated pulmonary arterial hypertension. *Lupus* 2006; **15**:138–142.

3 McGoon M, Gutterman D, Steen V, Barst R, McCrory DC, Fortin TA, Loyd JE. Screening, early detection, and diagnosis of pulmonary arterial hypertension: ACCP evidence-based clinical practice guidelines. *Chest* 2004; **126**:14S–34S.

4 Arcasoy SM, Christie JD, Ferrari VA, Sutton MS, Zisman DA, Blumenthal NP, *et al.* Echocardiographic assessment of pulmonary hypertension in patients with advanced lung disease. *Am J Respir Crit Care Med* 2003; **167**:735–740.

5 Devaraj A, Wells AU, Meister MG, Corte TJ, Hansell DM. The effect of diffuse pulmonary fibrosis on the reliability of CT signs of pulmonary hypertension. *Radiology* 2008; **249**:1042–1049.

6 Abbas AE, Fortuin FD, Schiller NB, Appleton CP, Moreno CA, Lester SJ. Echocardiographic determination of mean pulmonary artery pressure. *Am J Cardiol* 2003; **92**:1373–1376.

7 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**:609–616.

8 Tan RT, Kuzo R, Goodman LR, Siegel R, Haasler GR, Presberg KW. Utility of CT scan evaluation for predicting pulmonary hypertension in patients with parenchymal lung disease. *Chest* 1998; **113**:1250–1256.

9 Lick A, Danrad R, Smith D, Aiello D, Lammi M. Use of chest computed tomography angiogram as a predictor of diastolic dysfunction and pulmonary hypertension. *Chest* 2014; **146**:578A.

10 Li M, Wang S, Lin W, Li J, Wang C, Chen H, *et al.* Cardiovascular parameters of chest CT scan in estimating pulmonary arterial pressure in patients with pulmonary hypertension. *Clin Respir J* 2018; **12**:572–579.

11 Iyer AS, Wells JM, Vishin S, Bhatt SP, Wille KM, Dransfield MT. CT scan-measured pulmonary artery to aorta ratio and echocardiography for detecting pulmonary hypertension in severe COPD. *Chest* 2014; **145**:824–832.

12 Janda S, Shahidi N, Gin K, Swiston J. Diagnostic accuracy of echocardiography for pulmonary hypertension: a systematic review and meta-analysis. *Heart* 2011; **97**:612–622.