Al-Azhar International Medical Journal

Volume 4 | Issue 10 Article 8

2023
Section: Chest

# Correlation between the pulmonary artery diameter and its ratio to the aortic diameter in CT chest and the right ventricular function assessed by echocardiography in patients with pulmonary hypertension

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## How to Cite This Article

Mekky, Mohamed Adel Mohamed; El-Nady, Khaled M. Y.; Al-Sayd, Yasser Ahmed; and Al-Sayd, Mohamed Sedky (2023) "Correlation between the pulmonary artery diameter and its ratio to the aortic diameter in CT chest and the right ventricular function assessed by echocardiography in patients with pulmonary hypertension," *Al-Azhar International Medical Journal*: Vol. 4: Iss. 10, Article 8.
DOI: https://doi.org/10.58675/2682-339X.2000

ORIGINAL ARTICLE

# Correlation Between the Pulmonary Artery Diameter and its Ratio to the Aortic Diameter in CT Chest and the Right Ventricular Function Assessed by Echocardiography in Patients with Pulmonary Hypertension

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**Abstract**

*Background*: **he hemodynamic criteria for PAH is a pulmonary capillary wedge pressure of below 15 mm Hg and pulmonary vascular resistance (PVR) of higher than two Wood Units (WU), in addition to a mean pulmonary artery pressure of above 20 mm Hg. Because of its accessibility, non-invasiveness, and reproducibility, echocardiography is routinely employed in the diagnosis and monitoring of therapy for cases with PH.**

*Aim*: **To correlate the pulmonary artery diameter and its ratio to the aortic diameter in the CT chest and the right ventricular (RV) function measured by echocardiography (Echo) in cases with pulmonary hypertension (PH).**

*Patients and methods*: **This non-randomized interventional research performed in Maadi and Kobri Elkoba at the Armed Forces Medical Complex. One hundred individuals with RVSP more than 36 mmHg were analyzed.**

*Results*: **RVSP positively correlated with pulmonary artery (PA) diameter, *P*/A ratio and MPI. TAPSI negatively correlated with PA diameter, RVSP and MPI.**

*Conclusion*: **Impaired RV function occurs more with increased RVSP and increased pulmonary artery diameter in CT chest, PA diameter and *P*/A ratio in CT chest is correlated with RVSP and TAPSE.**

*Keywords:* CT chest, Echocardiography, Pulmonary artery diameter, Pulmonary hypertension

## 1. Introduction

Mean pulmonary artery pressure above 20 mm of mercury in the existence of a pulmonary capillary wedge pressure of below 15 mm Hg and a pulmonary vascular resistance >2 WU is diagnostic of PAH.[1]

Patients with PH often utilize Echo for diagnostic and therapeutic monitoring reasons because of its accessibility, non-invasiveness and reproducibility.[2]

In individuals with advanced lung illness, the mean pulmonary artery diameter as determined by computed tomography (CT) offers high diagnostic value for diagnosing PH.[3]

## 2. Materials and methods

This research was done in the Armed Forces Medical Complex in Maadi and Kobri Elkoba. The patients were selected from males and females words depending on their RVSP values. 100 patients

Accepted 10 June 2023.
Available online 7 November 2023

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https://doi.org/10.58675/2682-339X.2000

with RVSP above 36 mmg participated in the research.

The study consisted of 100 patients, the etiology for PH is pulmonary arterial hypertension (14 patients), lung diseases and/or hypoxia (61 patients), PH associated with pulmonary artery obstructions (8 cases) and PH with unclear or multi-factorial mechanisms (17 cases).

### 2.1. Inclusion criteria

This study was conducted on any patient complaining of shortness of breath along with symptoms of the original chest disease whose echo revealed right ventricular systolic pressure (RVSP) > 36 mmHg.

### 2.2. Exclusion criteria

Patients with poor echo window as morbid obesity or abnormal chest wall, critically ill patients and pregnant female and cases with PH because of left heart disease.

### 2.3. Methods

The following parameters were fulfilled for all the patients: Full history, Clinical examination, Echocardiography and Chest CT.

The research was accredited by The Ethics committee of faculty of medicine, Al-Azhar University. After clarification of this intervention to the participants, an agreement for involvement in this research was applied by every participant.

### 2.4. Statistical analysis

Microsoft Excel 2016 for Windows, part of the Microsoft Office 2016 package; 2016 of Microsoft Corporation, USA, was utilized to gather, code, and enter data into a spreadsheet. The data was investigated utilizing IBM's SPSS (Statistical Package for the Social Sciences) for Windows, Version 26.0 (IBM Corp., Armonk, NY). The Kolmogorov–Smirnov test was utilized to calculate the distribution's normality. Numbers and percentages were employed for displaying categorical data, whereas the mean ± SD were applied to characterize continuous data. The cutoff for significance was set at <0.05.

## 3. Results

This table showed that Demographic data of the studied cases (Table 1).

*Table 1. Demographic data of included patients.*

| | Mean ± SD | Median (Min.–Max.) |
|---|---|---|
| Age | 51.31 ± 11.2 | 52 (26–75) |
| Sex *N* (%) | | |
| Male | 47 (47%) | |
| Female | 53 (53%) | |
| Right ventricular systolic pressure | 64.69 ± 24.63 | 55 (38–147) |
| Pulmonary artery diameter | 33.97 ± 4.5 | 33.75 (23–45.9) |
| Aortic diameter | 34.91 ± 4.11 | 34.93 (24.65–48.95) |
| Myocardial performance index | 0.92 ± 3.95 | 0.46 (0.28–40) |
| Tricuspid annular plane systolic excursion | 1.89 ± 0.45 | 2.1 (0.9–2.4) |
| *P*/A ratio | 0.98 ± 0.15 | 0.96 (0.57–1.48) |

*P*/A:pulmonary artery to ascending aorta diameter.

This table showed that differential diagnosis of the studied cases (Table 2).

This table showed that PA diameter highly positively correlated with RVSP ($r = 0.481$), MPI ($r = 0.562$) and *P*/A ratio ($r = 0.677$) while highly negatively correlated with TAPSE ($r = -0.463$) (Table 3).

This table showed that RVSP highly positively correlated ($P < 0.001$) with PA diameter ($r = 0.481$), MPI ($r = 0.930$) and *P*/A ratio ($r = 0.505$) while highly negatively correlated with TAPSI ($r = -0.952$) (Table 4).

This table showed that *P*/A ratio highly positively correlated with RVSP ($r = 0.505$), MPI ($r = 0.645$) and PA diameter ($r = 0.667$) while highly negatively correlated with TAPSE ($r = -0.513$) (Table 5).

*Table 2. Different diagnoses of included patients.*

| Diagnosis | Number |
|---|---|
| Interstitial lung diseases | 27 |
| COPD | 21 |
| Idiopathic pulmonary hypertension | 9 |
| CTEPH | 8 |
| Mediastinal tumors | 3 |
| Sarcoidosis | 4 |
| Bronchiectasis | 4 |
| Scleroderma | 3 |
| Graves disease | 2 |
| PLCH | 3 |
| Obstructive sleep apnea | 2 |
| Cystic fibrosis | 2 |
| End stage renal disease | 2 |
| Obesity hypoventilation | 4 |
| Sickle cell anemia | 2 |
| SLE | 2 |
| Emphysema | 1 |
| Fibrosing mediastinitis | 1 |

COPD, Chronic obstructive pulmonary disease; CTEPH, chronic thromboembolic pulmonary hypertension; PLCH, Pulmonary Langerhans cell histocytosis; SLE, Systemic Lupus Erythematosis.

*Table 3. Correlation among pulmonary artery diameter and different parameters.*

| | Pulmonary artery diameter | |
|---|---|---|
| | r | *P* value |
| Age | 0.043 | 0.671 NS |
| RVSP | 0.481 | <0.001 HS |
| MPI | 0.562 | <0.001 HS |
| TAPSE | −0.463- | <0.001 HS |
| *P*/A ratio | 0.677 | <0.001 HS |

*Table 4. Correlation between RVSP and different variables.*

| | RVSP | |
|---|---|---|
| | r | *P* value |
| Age | 0.192 | 0.055 NS |
| Pulmonary artery diameter | 0.481 | <0.001 HS |
| MPI | 0.930 | <0.001 HS |
| TAPSE | −0.952- | <0.001 HS |
| *P*/A ratio | 0.505 | <0.001 HS |

This table showed that MPI highly positively correlated with RVSP ($r = 0.930$), *P*/A ratio ($r = 0.645$) and PA diameter ($r = 0.562$) while highly negatively correlated with TAPSE ($r = -0.891$) (Table 6).

This table showed that TAPSE highly negatively correlated ($P < 0.001$) with PA diameter ($r = -0.463$) RVSP ($r = -0.952$), MPI ($r = -0.891$) and *P*/A ratio ($r = -0.513$) (Table 7).

## 4. Discussion

PH is referred to as a mean pulmonary artery pressure >20 mm of mercury and is further subdivided into five categories.[1] An elevated pulmonary arterial pressure diagnosis is crucial due to the poor prognosis related to PH.[4]

Although it is an invasive procedure with known risks, the diagnosis of PH is still best served by a right-sided cardiac catheterization.[5]

Patients suspected of being diagnosed with PH or individuals who have diffuse pulmonary disease with risk for PH frequently undergo CT. Furthermore, the CT structure of the pulmonary vasculature as a marker of elevated mPAP has been extensively studied.[6]

*Table 5. Correlation among P/A ratio and different variables.*

| | *P*/A ratio | |
|---|---|---|
| | r | *P* value |
| Age | 0.066 | 0.551 NS |
| RVSP | 0.505 | <0.001 HS |
| MPI | 0.645 | <0.001 HS |
| TAPSE | −0.513 | <0.001 HS |
| Pulmonary artery diameter | 0.677 | <0.001 HS |

*Table 6. Correlation between MPI and different variables.*

| | MPI | |
|---|---|---|
| | r | *P* value |
| Age | 0.175 | 0.082 NS |
| RVSP | 0.930 | <0.001 HS |
| TAPSE | −0.891 | <0.001 HS |
| Pulmonary artery diameter | 0.562 | <0.001 HS |
| *P*/A ratio | 0.645 | <0.001 HS |

The Framingham Heart Study revealed that the normal reference sex-specific CT threshold value for mPA for males is 29 mm, while for females it is twenty-seven mm and that the normal reference sex-specific PA ratio is 0.9 for both woman and man. These 2 radiological assessments may be beneficial for the early detection of 'silent diseases' of the circulatory and pulmonary systems.[7] Patients were considered to have PH when their RVSP by transthoracic echocardiography ≥36 mmhg.[8]

Our research consisted of 100 patients, The cause of PH is PAH (14 cases), lung disease and/or hypoxia (61 cases), PH associated with pulmonary artery obstructions (8 cases), and PH with unclear or multifactorial mechanisms (17 cases).In our research, 47% of the subjects were men and 53% were women, and their ages varied from 26 to 75, with mean ± SD = 51.31 ± 11.2.

Our study revealed a positive correlation among PA diameter and systolic pulmonary artery pressure ($r = 0.481$, p 0.001), as well as a positive correlation among *P*/A ratio and systolic pulmonary artery pressure ($r = 0.505$, $P < 0.001$). This finding was agreeing with those of Chen et al.,[9] who analyzed 221 cases as follows: 56 cases were enrolled in the PH group, which consisted of COPD-associated PH, while 165 cases were involved in the non-PH group. The systolic pulmonary artery pressure identified by Echo correlated with the mean PA diameter ($r = 0.508$, R2 = 0.258) and the main *P*/A ratio ($r = 0.544$, R2 = 0.296) ($P < 0.001$).

Results also concur with those of Devaraj et al.,[10] who examined the accuracy of CT and echocardiographic evaluations to determine whether the combination was more anticipated of PH than one

*Table 7. Correlation between TAPSE and different variables.*

| | TAPSE | |
|---|---|---|
| | r | *P* value |
| Age | −0.160 | 0.111 NS |
| RVSP | −0.952 | <0.001 HS |
| MPI | −0.891 | <0.001 HS |
| Pulmonary artery diameter | −0.463 | <0.001 HS |
| *P*/A ratio | −0.513 | <0.001 HS |

test alone and who assessed the likelihood of occurrence of novel CT indicators for PH. The study found that mPAP was significantly related to both PA diameter and ratio of main *P*/A ratio (R2 = 0.45; $P < 0.001$).

Moore et al.,[11] on the other hand, found no relationship among main pulmonary artery diameter and MPAP in 24 cases with PAH and CTEPH. In cases with pulmonary vascular disease, greater main PA diameter was related to reduced cardiac output ($r = 0.75$, $P < 0.001$) and elevated PVR ($r = 0.61$, $P < 0.0005$) as a result of occlusion of peripheral arteries.

Our study revealed an inverse correlation among RVSP and TAPSE ($r = -0.952$, $P < 0.001$), which corresponds to the findings of López-Candales A et al.,[12] who found an inverse correlation a among TAPSE and PASP ($r = -0.63$, $P < 0.001$).

Our research revealed a negative correlation among TAPSE and MPI ($r = -0.891$, $P =<0.001$). This finding agreed with those of Ibrahim A. et al.,[13] who contrasted a cohort of 64 cases (both genders) with (PH) categorized into 3 age groups with 47 healthy volunteers of the same age as a control. They chose participants from Tishreen university hospital in Lattakia in 2016 MPI was obtained from pulse and tissue Doppler, and a negative correlation among MPI and TAPSE ($P = 0.03$ $r = -0.21$) was observed.

Our research revealed a negative correlation among TAPSE and PA diameter ($r = -0.463$, $P < 0.001$) and *P*/A ($r = 0.513$, p0.001). This finding agreed with those of Tonelli AR et al.,[14] who examined cases with pulmonary arterial hypertension who underwent at least 2 Chest CT at separate visits. In 113 PAH cases, both scans corresponded to the use of intravenous contrast and CT scans were contrasted among pairs. During a mean (midspread) time variance among Chest CT of eight (midspread: 3.5–20.0) months, the main pulmonary artery diameter increased by 0.5 ± 1.8 mm (mean ± SD; $P = 0.008$). When Chest CT were carried out > twelve months apart ($n = 47$), the main pulmonary artery diameter raised or reduced in 40percent and 13percent of cases, respectively, by > 1 mm. A rise in main pulmonary artery diameter was linked to a reduction in PA compliance, a rise in RVSP, a deterioration in RV function, and a decrease in 6-MWT. 53 (46.9%) cases perished during a median (midspread) follow-up period of 33 (midspread: 4.5–47) months. Alteration for differences in time and slice thickness among Chest CT, age, sex, PAH etiology and PVR, the alteration in PA diameter was a substantial indicator of mortality (hazard ratio per mm rise: 1.33 (95% confidence interval: 1.11–1.61) ($P = 0.002$). Interestingly, a substantial association was observed between an increase in TAPSE and a decrease in PA diameter.

Our research showed that MPI positively correlated with RVSP ($r = 0.930$, $P < 0.001$).This outcome is in keeping with the findings of Ibrahim A. et al.,[13] who found a greater positive correlation among tMPI and RVSP ($r = 0.28$ $P = 0.02$).

Limitations of this research involve its relatively small sample size of some groups of cases.

### *4.1. Conclusion*

Cases with PH have a larger pulmonary artery diameter, impaired RV function is more prevalent with a larger RVSP and the pulmonary artery diameter and *P*/A ratio are linked to MPI-measured RV function.

## Authorship

All authors have a substantial contribution to the article.

## Disclosure

The authors have no financial interest to declare in relation to the content of this article.

### Conflicts of interest

The authors declared that there were NO conflicts of Interest.

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