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by Bambang Satoto

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A review of chest X-ray in pulmonary hypertension: correlation of right descending pulmonary artery diameter with mean pulmonary artery pressure



Tara Nareswari¹, Christina Hari Nawangsih Prihharsanti¹, Hermina Sukmaningtyas¹, Farah Hendara Ningrum¹, Bambang Satoto¹, Antonius Gunawan Santoso^{1*}

ABSTRACT

Background: Pulmonary hypertension is a condition which there is an increase in mean pulmonary artery pressure measured at ≥ 25 mmHg. The gold standard in diagnosing this condition is right heart catheterization. Enlargement of right descending pulmonary artery on chest radiographs is a sign of pulmonary hypertension. However, the value of radiographic measurements reported was diverse. The study analyzes the correlation between the right descending pulmonary artery (RDPA) diameter on chest radiographs and means pulmonary artery pressure on right heart catheterization to understand whether RDPA diameter on chest X-ray could be a predictor in determining the severity of pulmonary hypertension.

Methods: Thirty-five subjects were reviewed to compare RDPA diameter from a chest X-ray on posteroanterior projection and mPAP value from the right heart catheterization. The correlation between them was analyzed using Pearson's correlation test. RDPA diameter cut-off point was defined using the ROC curve.

Result: RDPA diameter and mPAP revealed a high positive correlation ($p < 0.001$; $r = 0.824$). The cut-off value of the RDPA diameter was 21.8 mm (sensitivity 81% and specificity 85.7%; $AUC = 0.9$).

Conclusion: The measurement of right descending pulmonary artery diameter on chest x-ray positively correlates with mean pulmonary artery pressure. Therefore, the diameter of the right pulmonary artery on the chest x-ray can predict the severity of pulmonary hypertension.

Keywords: mPAP, Pulmonary hypertension, RDPA diameter.

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¹Department of Radiology, Faculty of Medicine, Universitas Diponegoro-Dr. Kariadi Hospital Semarang, Indonesia.

*Corresponding author:
Antonius Gunawan Santoso;
Department of Radiology, Faculty of Medicine, Universitas Diponegoro-Dr. Kariadi Hospital Semarang, Indonesia;
santoso_gun@yahoo.com

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INTRODUCTION

Pulmonary hypertension is pathological changes of the pulmonary circulation that results in increased pulmonary artery pressure. It is defined as an increase in mean pulmonary arterial pressure (mPAP) ≥ 25 mmHg by right heart catheterization.¹ The increased intravascular pressure can be caused by various factors, resulting in pathological changes in the vessel wall, with the occurrence of vascular remodeling. These conditions lead to vascular remodeling result in hypertrophy and dilation.²

Regardless of the various etiological cause, pulmonary hypertension can manifest with or without clinical signs and symptoms. If pulmonary hypertension is not resolved immediately, it will be worsening, resulting in severe right

heart dysfunction and death. A clinician must make the diagnosis of pulmonary hypertension as early as possible.

Definite diagnosis of pulmonary hypertension is made by right heart catheterization. However, this is a high-risk invasive procedure, costly, and requires a complex equipment and experts so not all hospitals can carry out this procedure. Therefore, an alternative diagnostic tool is required to predict pulmonary arterial pressure.³

Imaging modalities, such as computed tomography (CT), magnetic resonance imaging (MRI), and chest X-ray, can assess pulmonary vascular dilation, cardiac and lung parenchyma changes. Chest X-ray examination of the posteroanterior position has shown a good correlation in predicting pulmonary hypertension by measuring the right descending

pulmonary artery diameter. A study by Lin et al. proved a correlation between right descending pulmonary artery (RDPA) diameter and systolic pulmonary artery pressure (sPAP) by echocardiography in 229 subjects and Chhabra et al. conducted a study on 50 patients with chronic obstructive pulmonary disease (COPD).⁴ It has proven there is a correlation between the hilar thoracic index and RDPA diameter with sPAP and mPAP echocardiography.⁵

In previous studies, the measurement of arterial pressure was obtained using echocardiography. In this study, it was determined by right heart catheterization as the gold standard procedure in measuring arterial pressure. Previous studies also did not provide the cut-off point of pulmonary artery diameter as a predictor of severity pulmonary hypertension. Aside from that,

chest X-ray is the most frequently used and widely available, so it inspired the authors to analyze the correlation of the right descending pulmonary artery diameter on conventional chest X-ray with mean pulmonary arterial pressure (mPAP) as a predictor of pulmonary hypertension.

METHODS

This research was a retrospective and observational analytic study with a cross-sectional design. Samples obtained from the medical records of patients with pulmonary hypertension who underwent right heart catheterization at Dr. Kariadi Hospital, from January 2018 to July 2020.

A consecutive sampling method was used in this study. Medical record data were collected from patients who underwent right heart catheterization and chest radiographs in Dr. Kariadi Hospital Semarang, and selected using inclusion criteria. The mPAP value data obtained from the results of the right heart catheterization examination.

The inclusion criteria are patients that more than equal to 18 year old, have mPAP more than equal to twenty-five millimeters of mercury in right heart catheterization procedure, and chest X-ray is taken on the same day before or at least 2 months before cardiac catheterization procedure. The exclusion criteria are chest x-ray examination with inadequate inspiration and mediastinal mass

Data on the right descending pulmonary artery diameter were obtained from chest X-ray reader using Radiant dicom 1.3.9 Beta software with 100% magnification and the same brightness or penetration, which was confirmed from the vertebral bodies should just be visible through the heart.

Measurement of the right descending pulmonary artery diameter on a chest X-ray was performed by measuring the transverse diameter at the most proximal point of the right descending pulmonary artery and perpendicular to the lumen structure of this vessels. Measurements were taken three times and calculated to get the mean RDPA diameter to avoid parallax errors.

Data analysis is carried out in three steps. First, descriptive step, the data was verified once it was collected entirely.

Table 1. Characteristics of research subjects (n=35)

Characteristic	F	%	Mean	SD	Median	Minimum	Maximum
Category mPAP							
Mild	8	11.4					
Moderate	6	17.1					
Severe	21	60.1					
Gender							
Male	9	25.7					
Female	26	74.3					
Age	6	17.1	33.2	12.2	31	18	66

Table 2. Results of measurements of mPAP and diameter of the right descending pulmonary artery (RDPA) (n= 35).

Variable	Mean ± SD	Median	Minimum - Maximum
mPAP (mmHg)	48.8 ± 17.2	50	25 - 78
RDPA (mm)	22.90 ± 5.15	22.60	13.5 - 33.2

Table 3. The right descending pulmonary artery diameter based on the mPAP category.

mPAP	Mean ± SD	Median	Minimum - Maximum
Mild	18.25 ± 1.12	18.35	16.8 - 19.5
Moderate	22.0 ± 2.87	21.25	18.9 - 25.8
Severe	23.86 ± 5.57	23.9	13.5 - 33.2

Table 4. Analysis of the cut-off point of the right descending pulmonary artery diameter.

RDPA Diameter	mPAP		P	RR (95% CI)
	Severe	Non-severe		
"wide" (≥21.8 mm) (n=19)	17 (89.5%)	2 (10.5%)	<0.001	3.6 (1.5-8.5)
"not wide" (<21.8 mm) (n=16)	4 (25.0%)	12 (75.0%)		

Sensitivity 81% dan specificity 85.7%.

Then, data will be presented in tabulated form, either single or cross.

Second, bivariate analysis was done to test the hypothesis. We use Pearson Correlation Test because the data was normally distributed. Lastly, we determined the cut-off point and the confidence interval based on the Receiver operating characteristic curve (ROC) and the highest sensitivity and specificity.

RESULTS

Eighty-four subjects underwent right heart catheterization during that period and had a chest X-ray examination at Dr. Kariadi Hospital. In the process of obtaining the data, there were some difficulties. First, the absence of some chest X-ray file. Second, some patients were ruled out from this study because of hilar area was superpositioned with the heart border or

close opacity which could be a suspicion of lymphadenopathy or a mediastinal mass. Thirty-five subjects met the criteria for this study.

The 35 subjects consist of 9 men (25.7%) and 26 women (74.3%), the youngest is 18 year old and the oldest is 66 year old. In this study classified into mild, moderate, and severe categories as mPAP 25–35, 35–45, and >45 mmHg, respectively (Table 1). The mPAP results are mild pulmonary hypertension in 8 subjects, moderate pulmonary hypertension in 6 subjects, and severe pulmonary hypertension in 21 subjects (Table 2).

Right descending pulmonary artery diameter based on mPAP category could be seen in table 3. The results of the data normality test showed that the mean pulmonary artery pressure and right descending pulmonary artery diameter

were normally distributed ($p > 0.05$), and the test results obtained p values < 0.001 and $r = 0.824$ which proved strong significant evidence between mean pulmonary arterial pressure and the diameter of the right descending pulmonary artery diameter with a positive tendency.

In this study, a statistical analysis of ROC (operating characteristics of the recipient) was performed to determine the cut-off point of the right descending pulmonary artery diameter. This cut-off point is expected to be useful in determining the severity of pulmonary hypertension from chest X-ray. Determination of cut-off point was using 2 categories. Severe is defined as > 45 mmHg and non-severe is defined as ≤ 45 mmHg. From this study, the cut-off results were 21.8 mm with a fairly large area under the curve with a sensitivity of 81% and a specificity of 85.7% (Table 4).

DISCUSSION

In this study, the right descending pulmonary artery (RDPA) diameter on chest x-ray significantly correlated with mPAP on right heart catheterization. Overall results of this study showed that RDPA diameter is the parameter that can predict pulmonary artery hypertension. The cut-off point for diagnosing pulmonary artery hypertension is 21.8 mm with specificity was 85.7% and sensitivity was 81%.

Chest X-ray is a simple, affordable, and widely available imaging modality that is considered as a useful tool for screening patients with elevated pulmonary pressure. Measuring the RDPA diameter for predicting pulmonary hypertension on chest X-ray has been evaluated in previous studies.

Lin et al. demonstrated that RDPA diameter on chest x-ray significantly correlated with echocardiography-estimated systolic pulmonary artery pressure (SPAP). The limitations and potential sources of bias in this study was the ROC analysis that measured by echocardiography instead of heart catheterization. Thus, the sensitivity and specificity might be biased. Their study did not find any satisfactory RDPA

cut-off point for predicting pulmonary hypertension.⁵

Chhabra et al. analyzed the relationship between RDPA diameter on chest X-ray and echocardiography-estimated SPAP. They found the correlation was significant ($r = 0.42$, $p < 0.05$). The RDPA diameter more than 20 mm was identified in patients with pulmonary hypertension. Its specificity was 100%, but sensitivity and negative predictive value were low (41% and 20%, respectively).⁶

From the studies above, measurement of pulmonary artery pressure was obtained by echocardiography. This study is different because we estimated pulmonary arterial pressures by right heart catheterization. The results of this study have similarities with previous study that the larger RDPAD, the higher pulmonary artery pressure is. This condition occurred because the high intravascular pressure can increase pulmonary arteriole contractility, damage endothelial pulmonary vascular that lead to reduction of endothelial barrier function and increase vascular wall shear stress. These conditions lead to vascular remodeling result in hypertrophy and dilation.²

CONCLUSION

In conclusion, evaluating the RDPA diameter in Chest X-Ray is a valuable method to predict severity pulmonary hypertension. The cut-off point to predict the severity of pulmonary hypertension is 21.8 mm. We hoped that this research could be a preliminary for further study and there will be further research using different imaging modalities.

ETHICAL APPROVAL

Health Research Ethics Commission of Dr. Kariadi Hospital Semarang No. 550/EC/KEPK-RSDK/2020.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

Tara Nareswari; conceived of the presented idea, developed the theory and performed the computations, processed the experimental data, performed the analysis, and drafted the manuscript. Christina Hari Nawangsih Priharsanti, Hermina Sukmaningtyas, Farah Hendara Ningrum, Bambang Satoto, Antonius Gunawan Santoso; support, supervised this study, contributed to the design and implementation of the research. All authors provided critical feedback and helped shape the research, analysis, and manuscript.

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