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Evaluation of the Relationship between Chest Radiography Findings and Pulmonary Artery Pressure during Right Heart Catheterization

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Abstract

Background: Pulmonary artery hypertension is difficult to diagnose because of its nonspecific symptoms. Although echocardiography and more accurately catheterization can recognize pulmonary artery pressure, chest X-ray is widely used because of its availability.
Objectives: This study was to evaluate the accuracy of chest radiography parameters for the estimation of pulmonary artery pressure.
Methods: This cross-sectional study included 81 subjects with a definite diagnosis of pulmonary artery hypertension. Mean pulmonary artery pressure (mPAP) was determined by catheterization. Hilar enlargement, projection of the right heart border (PRHB), hilar enlargement + PRHB, and the ratio of these parameters to the thoracic diameter were compared to mPAP to evaluate correlations.
Results: The average mPAP was 74.7±21 (ranging from 28 to 120 mmHg). Spearman's test revealed that mPAP had a significant correlation with a hilar enlargement (r=0.489, P<0.001), hilar/thoracic ratio (r=0.482, P<0.001), hilar enlargement + PRHB (r= 0.517, P<0.001), and hilar + PRHB/thoracic ratio (r=463, P<0.001).
Conclusion: Hilar enlargement and hilar/thoracic ratio on the chest radiography are proper parameters for the estimation of pulmonary artery pressure.

Keywords: Catheterization, Chest radiography, Pulmonary artery hypertension, Pulmonary artery pressure

1. Background

At the 6th World Pulmonary Hypertension Symposium in France in 2018, pulmonary arterial hypertension (PAH) was defined as mean pulmonary artery pressure > 20 (Mean Pulmonary Artery Pressure). Since it can be treated to reduce the death toll, diagnosing PAH is paramount (1-3). This disorder can lead to right heart failure and death if left untreated. It is a rare cause of shortness of breath; however, it is recommended that a physical examination of the chest, a pulmonary function test, and a normal chest radiograph be performed in PAH. Depending on the etiology, its prevalence is different; nevertheless, it has been reported that 326 people out of every 100,000 who undergo echocardiography have pulmonary hypertension, according to a recent study (4). The significance of PAH could be observed more often in the population above 50 years of age. Pulmonary hypertension is the third most common cardiac complication after coronary artery diseases and myocardial infarction (5). When looking at the signs and symptoms of pulmonary hypertension, many patients present symptoms like functional shortness of breath and chest pain and lethargy, fatigue, or other signs, such as hepatomegaly and peripheral edema (6). Various paraclinical methods are commonly used to evaluate patients in the clinic after carefully examining the signs and symptoms (7-9).

The three-year mortality rate for patients with elevated pulmonary artery pressure is 30-40% (10). Diagnosing PAH is difficult in the early stages due to the lack of symptoms and signs. Electrocardiogram, chest X-ray, and echocardiography are the three most commonly used diagnostic methods for patients with pulmonary artery pressure abnormalities after carefully examining clinical signs and symptoms (7). Furthermore, a confirmed diagnosis depends on the pulmonary artery pressure, which is measured by right heart catheterization (10).

Although used widely as a primary screening and diagnostic test, the diagnostic accuracy of echocardiography is not high (11, 12). A chest X-ray is typically used in cardiopulmonary patients as a non-invasive tool for examination, and numerous factors, such as right descending pulmonary artery (RDPA) and left descending pulmonary artery (LDPA) diameters, have been studied in various studies (13-15). Because the diameters of RDPA and LDPA on a graph may not be visible in some cases, hilar enlargement and its hilum/chest ratio may be good diagnostic criteria for patients of various sizes, reducing errors (16). However, the compatibility of lung radiographic findings with right heart catheterization findings has not yet been examined. The risks of right heart catheterization are similar to those of other invasive procedures. Therefore, by determining the compatibility of this method with other less invasive and more available methods, patients who do not need this procedure could be spared in terms of time and costs.

A study conducted by Mirsadraei et al. examined

100 patients to discover the most effective chest radiography parameters for finding elevated pulmonary artery pressure (16). An echocardiographic evaluation of pulmonary artery pressure in this study found that there is a strong correlation between hilar enlargement and hypertension. The strongest link was found between the degree of projection of the right heart border (PRHB) alone and PRHB + hilar enlargement.

2. Objectives

In this study, we intended to investigate the correlation between chest radiographic findings and mean pulmonary artery pressure in right heart catheterization in patients with PAH, and by determining the findings, reduce the cost and time imposed on the patients.

3. Methods

This cross-sectional study was conducted on patients who underwent right heart catheterization to measure pulmonary artery pressure and had a digital chest photograph at the medical centers of Imam Reza and Ghaem in Mashhad, Iran. The patients were explained all the benefits of the study and informed consent was obtained from them or their guardians.

The Organizational Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran, conducted this research with the IR code.MUMS.MEDICAL.REC.1400.384.

Rotated or poor-quality X-rays were removed from the study. Radiologists performed blind interpretations of digital chest X-ray images to obtain the measurements for hilar enlargement, PRHB, and thoracic diameter, as shown in fig 1. In the next step, SPSS statistical software was used to examine the correlation between pulmonary artery pressure measured by right heart catheterization and the findings on the chest images of the patients.

4. Results

Eighty-one patients with PAH who had undergone right heart catheterization and chest X-rays participated in this research. Nineteen (23.5%) cases of the study population were male, while 62 (76.5%) were female. In this study, patients were in the age range of 19-88 years old.

Right heart catheterization yielded an average pulmonary artery pressure of 74 mm of mercury (28-120 mm Hg). Radiological findings, including hilar enlargement and PRHB, hilar enlargement + PRHB, hilum/thorax ratio, and PRHB/thorax ratio, are presented in Table 1. The average hilar enlargement was 132 mm (minimum 112 mm and maximum 165 mm). The average PRHB was 56 m, with a range of 40-75 mm.

Table 1. Quantitative data on the study population

	Age	PAP	Hilar	PRHB	Hilar+PRHB	Hilar /thoracic	PRHB/thoracic	Hilar+PRHB /thoracic
Average ±	42.6±	74.7 ±	132.3±	56.1 ±	188.4±	0.52 ±	0.22 ±	0.75±
Standard Deviation	15.4	21.4	12.2	8.6	16.3	0.56	0.37	0.07
Minimum	19	28	112	40	160	0.43	0.15	0.59
Maximum	88	120	165	75	240	0.70	0.31	0.97

PAP: Pulmonary artery pressure; PRHB: Projection of the right heart border

Table 2. Correlation between radiological factors and PAH in the study population

	Hilar	PRHB	Hilar+PRHB	Hilar /thoracic	PRHB /thoracic	Hilar+PRHB /thoracic
***R**	0.489	0.274	0.517	0.482	0.256	0.463
P-value	<0.001	0.013	<0.001	<0.001	0.021	<0.001

PRHB: Projection of the right heart border
*Spearman test

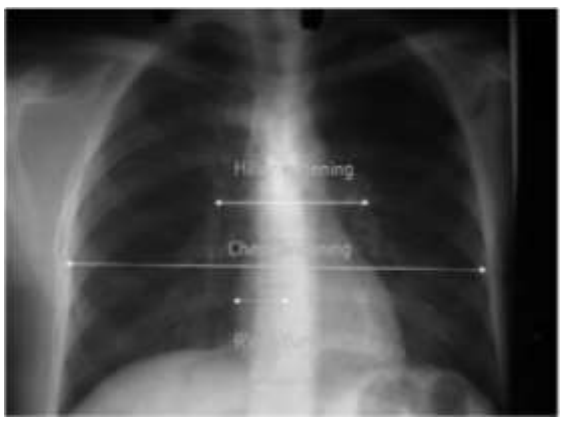

Fig 1. Measuring the research's radiological indicators

The Spearman test was used to determine the correlation between each radiological factor and pulmonary artery pressure, which showed a significant correlation (P<0.001) between PAH and these factors: hilar enlargement (r=0.489), hilar enlargement + PRHB (r=0.517), hilar enlargement/thorax (r=0.482), hilar enlargement magnitude + PRHB/thorax (r=0.463) (Table 2).

5. Discussion

For screening patients with PAH, chest X-rays are a simple, inexpensive, and accessible diagnostic method (17). The diameters of the RDPA and LDPA are the most commonly used criteria in various studies to diagnose PAH in chest X-rays. Although it was mentioned in a study that the accuracy of this parameter was low due to the quality of chest X-rays (64%), the hilum diameter is always clear in the images unless covered by an opacity (18). Pulmonary hypertension can be diagnosed by measuring the main pulmonary artery's diameter, which has been shown in other studies to be related to pulmonary artery pressure (19-21). This finding is consistent with those of our study. However, while echocardiography was used in the cited studies, we used catheterization, and no articles were found regarding the relationship between radiological findings and pulmonary artery pressure measured by catheterization. Despite the small sample size, the pulmonary artery pressure measurements were more accurate using catheterization.

Mattie et al. found that the sensitivity, specificity, and overall accuracy of RDPA enlargement were 72%, 93%, and 77%, respectively, to detect an increase in pulmonary arterial pressure in patients with chronic obstructive pulmonary disease (COPD). The author concluded that the overall accuracy of this method was lower than that of the RDPA and LDPA measurements (22,23). Furthermore, the results of another study recommended no cut-off using RDPA to diagnose PAH. Due to their invisibility, these indicators were included in a few graphs in our study.

A new indicator, the hilum/thorax ratio, was evaluated in a study by Chetty et al. on COPD patients. The findings of this study showed that the hilum/thorax with a 0.36 cut-off had 95% sensitivity and 100% specificity and was reported as the best indicator for diagnosing PAH. The sensitivity and specificity of RDPA with a cut-off of 20 mm were reported to be 95% and 79%, respectively, in this study (24). Our study also examined this ratio, which appeared to be particularly useful for patients with unusually large bodies.

It was found in the study by Mirsadraei et al. that pulmonary systolic blood pressure had a significant relationship with hilar enlargement, which was consistent with our findings. However, the pulmonary artery pressure was measured using echocardiography in this study. Pulmonary artery pressure and hilar enlargement had the highest levels of significance when compared to PRHB alone and hilar enlargement + PRHB. Based on the results of this study, the highest sensitivity was obtained by setting cuts for hilar enlargement as > 112 mm, PRHN as > 44 mm, and hilum/thorax as > 0.44 (16).

Considering the earlier mentioned factors, such as the invisibility of LDPA and RDPA in the chest X-rays of many patients, numerous studies have utilized radiological parameters in a thoracic ratio to eliminate the effects of different body sizes. The radiological findings in our study were hilar enlargement, PRHB, and hilar enlargement + PRHB and their ratio to the thorax. Hilar enlargement (r=0.489), hilar enlargement + PRHB (r=0.517), hilar enlargement/thorax (r=0.482), and hilar enlargement magnitude + PRHB/thorax had a significant correlation with PAH (P<0.001). It was found that PRHB had no strong correlation with PAH, and it should be mentioned that right heart enlargement was a delayed finding and would not significantly change in the early stages.

The main limitations of the present study were the sample size and the lack of a control group since healthy people could not undergo catheterization to measure PAP. Therefore, the present study findings could not effectively diagnose PAH; however, they could follow up with those with PAH at an acceptable accuracy rate.

6. Conclusion

Hilar enlargement and hilum/thorax ratio in chest X-rays significantly correlate with PAP in patients with pulmonary hypertension. This tool could be used to follow up with patients and reduce the error of body size variations and misinterpretation of the hilum/thorax ratio. However, larger sample sizes and studies involving a control group are recommended for a more thorough investigation.

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Conflicts of interest

No conflict of interest is declared.

References

1. Simonneau G, Montani D, Celermajer DS, Denton CP, Gatzoulis MA, Krowka M, et al. Haemodynamic definitions and updated clinical classification of pulmonary hypertension. Eur Respir J. 2019 Jan 24;53(1):1801913..
2. Douschan P, Kovacs G, Avian A, Foris V, Gruber F, Olschewski A, et al. Mild Elevation of Pulmonary Arterial Pressure as a

Predictor of Mortality. Am J Respir Crit Care Med. 2018 Feb 15;197(4):509-516.
3. McGoon M, Gutterman D, Steen V, Barst R, McCrory DC, Fortin TA, et al; American College of Chest Physicians. Screening, early detection, and diagnosis of pulmonary arterial hypertension: ACCP evidence-based clinical practice guidelines. Chest. 2004 Jul;126(1 Suppl):14S-34S.
4. Strange G, Playford D, Stewart S, Deague JA, Nelson H, Kent A, et al. Pulmonary hypertension: prevalence and mortality in the Armadale echocardiography cohort. Heart. 2012 Dec;98(24):1805-11.
5. Nauser TD, Stites SW. Diagnosis and treatment of pulmonary hypertension. Am Fam Physician. 2001 May 1;63(9):1789-98
6. Frost A, Badesch D, Gibbs JSR, Gopalan D, Khanna D, Manes A, et al. Diagnosis of pulmonary hypertension. Eur Respir J. 2019 Jan 24;53(1):1801904.
7. Altschul E, Remy-Jardin M, Machnicki S, Sulica R, Moore JA, Singh A, et al. Imaging of Pulmonary Hypertension: Pictorial Essay. Chest. 2019 Aug;156(2):211-227.
8. Hachulla E, Carpentier P, Gressin V, Diot E, Allanore Y, Sibilia J, et al. ItinérAIR-Sclérodermie Study Investigators. Risk factors for death and the 3-year survival of patients with systemic sclerosis: the French ItinérAIR-Sclérodermie study. Rheumatology (Oxford). 2009 Mar;48(3):304-8.
9. Cappola TP, Felker GM, Kao WH, Hare JM, Baughman KL, Kasper EK. Pulmonary hypertension and risk of death in cardiomyopathy: patients with myocarditis are at higher risk. Circulation. 2002 Apr 9;105(14):1663-8
10. Fukuda K, Date H, Doi S, Fukumoto Y, Fukushima N, Hatano M, et al. Japanese Circulation Society and the Japanese Pulmonary Circulation and Pulmonary Hypertension Society Joint Working Group. Guidelines for the Treatment of Pulmonary Hypertension (JCS 2017/JPCPHS 2017). Circ J. 2019 Mar 25;83(4):842-945.
11. O'Leary JM, Assad TR, Xu M, Farber-Eger E, Wells QS, Hemnes AR, et al. Lack of a Tricuspid Regurgitation Doppler Signal and Pulmonary Hypertension by Invasive Measurement. J Am Heart Assoc. 2018 Jun 30;7(13):e009362.
12. Homma A, Anzueto A, Peters JI, Susanto I, Sako E, Zabalgoitia M, Bryan CL, et al. Pulmonary artery systolic pressures estimated by echocardiogram vs cardiac catheterization in patients awaiting lung transplantation. J Heart Lung Transplant. 2001 Aug;20(8):833-9.
13. CHANG CH. The normal roentgenographic measurement of the right descending pulmonary artery in 1,085 cases. Am J Roentgenol Radium Ther Nucl Med. 1962 May;87:929-35
14. Sanchez O, Revel MP, Couchon S, Meyer G. Imagerie de l'hypertension artérielle pulmonaire [Imaging of pulmonary arterial hypertension]. Rev Mal Respir. 2007 Feb;24(2):155-69.
15. Lee Y, Choi W, Lee D, Chang J, Kang JH, Choi J, Chang D. Correlation between caudal pulmonary artery diameter to body surface area ratio and echocardiography-estimated systolic pulmonary arterial pressure in dogs. J Vet Sci. 2016 Jun 30;17(2):243-51
16. Mirsadraee M, Nazemi S, Hamedanchi A, Naghibi S. Simple screening of pulmonary artery hypertension using standard chest x ray: an old technique ,new landmark. Tanaffos. 2013;12(3):17-22.
17. Matthay RA, Niederman MS, Wiedemann HP. Cardiovascular-pulmonary interaction in chronic obstructive pulmonary disease with special reference to the pathogenesis and management of cor pulmonale. Med Clin North Am 1990; 74 (3): 571- 618.
18. Teichmann V, Jezek V, Herles F. Relevance of width of right descending branch of pulmonary artery as a radiological sign of pulmonary hypertension. Thorax 1970; 25 (1): 91- 6.
19. 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 Feb;254(2):609-16.
20. Ng CS, Wells AU, Padley SP. A CT sign of chronic pulmonary arterial hypertension: the ratio of main pulmonary artery to aortic diameter. J Thorac Imaging 1999; 14:270–278.
21. Condliffe R, Radon M, Hurdman J, Davies C, Hill C, Akil M, et al. CT pulmonary angiography combined with echocardiography in suspected systemic sclerosis-associated pulmonary arterial hypertension. Rheumatology (Oxford). 2011 Aug;50(8):1480-6.
22. Matthay RA, Schwarz MI, Ellis JH Jr, Steele PP, Siebert PE, Durrance JR, et al. Pulmonary artery hypertension in chronic obstructive pulmonary disease: determination by chest radiography. Invest Radiol 1981; 16 (2): 95- 100.
23. Lin SC, Chen RJC, Lee JH. The correlation between right descending pulmonary artery diameter and echocardiographyestimated systolic pulmonary artery pressure. Acta Cardiol Sin 2009; 25: 213- 7.
24. Chetty KG, Brown SE, Light RW. Identification of pulmonary hypertension in chronic obstructive pulmonary disease from routine chest radiographs. Am Rev Respir Dis 1982; 126 (2): 338- 41.