ORIGINAL RESEARCH

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Association Between Pulmonary Artery Diameter on Computed Tomography and Pulmonary Artery Pressure in Lung Transplant Recipients

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Abstract

Objective: This study aims to evaluate the correlation between pulmonary artery diameter (PAD) measured by computed tomography (CT) and pulmonary artery systolic pressure (PASP) measured by right heart catheterization (RHC) in patients undergoing lung transplantation.

Materials and Methods: This retrospective study included 88 patients who underwent lung transplantation at a tertiary hospital in İstanbul between 2013 and 2021. Patients with available data on PASP measured by RHC and PAD measured by CT were included in the analysis. Data obtained from both the preoperative and postoperative periods were analyzed using the Pearson correlation test.

Results: The mean age of the 88 patients included in the study was 44.5±13.5 years, and 78.4% were male. The mean PASP measured by RHC was 43.44±14.17 mmHg, while the value measured by echocardiography was 38.08±12.71 mmHg. The mean main PAD value measured by preoperative CT was 3.17±0.52 cm. A higher correlation was observed between PAD and PASP in the preoperative period ($r=0.773$; $p<0.001$), while a lower correlation was found in the postoperative period ($r=0.575$; $p<0.001$).

Conclusion: This study demonstrated a strong correlation between PAD measured by CT and pulmonary arterial pressure measured by RHC, particularly in the preoperative period, in patients undergoing lung transplantation. This finding represents a significant advancement in clinical practice, as it may help reduce complication risks and improve patient comfort.

Keywords: Pulmonary artery, catheterization, lung transplantation, computed tomography

Introduction

Lung transplantation is regarded as one of the most effective treatment options for patients with end-stage lung diseases. Accurate assessment of hemodynamic parameters in both the preoperative and postoperative periods is essential for ensuring optimal patient management. Among these parameters, pulmonary artery systolic pressure (PASP) serves as a key indicator for evaluating pulmonary vascular resistance and the risk of right heart failure. Traditionally, PASP is measured through right heart catheterization (RHC), an invasive but highly reliable method that enables quantitative assessment of pressure, flow, and vascular resistance [1]. Despite its accuracy, RHC carries a risk of complications and may not be feasible for frequent evaluations in all patients [1].

Echocardiography, a non-invasive technique, is frequently used as a screening tool for pulmonary hypertension (PH) [2,3]. However, factors such as obesity, postoperative anatomical changes, and pulmonary parenchymal hyperinflation may limit the accuracy of echocardiographic measurements, thereby necessitating alternative non-invasive assessment methods [4].

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Computed tomography (CT) and magnetic resonance imaging (MRI) offer significant advantages in overcoming these challenges due to their high-resolution, cross-sectional imaging capabilities. An MRI study involving patients with primary pulmonary hypertension (PPH) demonstrated a strong correlation (r=0.7, p<0.01) between mean PASP and the ratio of the pulmonary artery diameter (PAD) to the descending thoracic aorta diameter [5]. However, this ratio becomes less reliable in cases where the aorta is dilated. Moreover, MRI is time-consuming, costly, and less accessible, making CT a more practical alternative. CT also offers the added benefit of lung parenchyma simultaneously.

Recently, CT-based measurements of PAD have been proposed as a non-invasive method for assessing PH [6]. Several studies have reported a significant correlation between CT-derived PAD and PASP values [7,8]. However, research directly comparing CT and RHC measurements in lung transplant patients, both preoperatively and postoperatively, remains limited [9].

This study aims to investigate the correlation between PASP values measured by RHC and PADs obtained from CT in lung transplant recipients.

Materials and Methods

Study Design and Population

This retrospective observational study was conducted on patients who underwent lung transplantation at University of Health Sciences Türkiye, Kartal Koşuyolu High Specialization Education and Research Hospital between January 1, 2013, and November 1, 2021. The study was carried out after receiving approval from the Ethics Committee of the relevant institution (decision number: 2021/14/540, date: 19.10.2021). Patient confidentiality was maintained, and the study was conducted in accordance with the Declaration of Helsinki. Written informed consent forms were obtained from all patients.

Patient Selection and Inclusion Criteria

Patients who underwent lung transplantation during the study period and for whom PASP data measured by RHC were available were included. In addition, patients whose PAD was measured via thoracic CT during the same period were also enrolled. Patients with missing data, those who did not undergo thoracic CT, or those for whom the PAD could not be evaluated due to technical limitations were excluded.

Data Collection

Demographic data (age, gender) and the date of surgery were collected retrospectively from the hospital records. PASP values measured by RHC, tricuspid annular plane systolic excursion, pulmonary vascular pressure, and preoperative echocardiographically measured pulmonary arterial pressure (PAP) values were retrospectively obtained from the hospital data system. Additionally, the aortic and PAD measurements obtained from CT images of the same patients were recorded. The PAD measurements were evaluated based on the main PAD both preoperatively and postoperatively.

Statistical Analysis

The data utilized in the study were analyzed using the SPSS 25.0 for Windows® statistical software package (IBM Inc., Chicago, IL, USA). For continuous variables, the mean ± standard deviation and the 25th-75th interquartile ranges were calculated. Pearson correlation analysis was performed to evaluate the relationship between the PASP values measured by RHC and the PAD measurements obtained from CT. A p-value of <0.05 was considered statistically significant.

Results

A total of 88 patients were included in the study. The mean age was 44.5±13.5 years (minimum: 14, maximum: 64). Sixty-nine patients (78.4%) were male. The mean age of female patients was lower than that of male patients (36.5±13.9 vs. 46.7±12.6; p=0.008). Among the patients, 31 (35.2%) had interstitial lung disease, 25 (28.4%) had bronchiectasis, and 21 (23.9%) had chronic obstructive pulmonary disease (Table 1).

The highest number of lung transplants occurred in 2017 (n=26, 29.5%), followed by 2018 (n=25, 28.4%) and 2019 (n=15, 17.0%). A significant decrease was observed after 2020 (Figure 1).

The mean values of PASP measurements obtained via catheterization in the study cohort were 43.44±14.17 mmHg. The mean PASP values measured by echocardiography before the operation were 38.08±12.71 mmHg (Table 2).

Pearson correlation tests were performed between the pulmonary artery measurements taken from thoracic CT images of the patients pre-operation and post-operation and the PASP values obtained by echocardiography and catheterization. A positive correlation was found between the preoperative PAD measurements and both preoperative echocardiographic PASP (C: 0.747, p<0.001) and catheter-

Table 1. Distribution of lung transplant patients by etiology

Diagnosis	Frequency, n	Percent, %
Interstitial lung disease	31	35.2
COPD	21	23.9
Pulmonary vascular diseases	3	3.4
Sarcoidosis	3	3.4
Occupational diseases	4	4.5
Bronchiectasis	25	28.5
Other	1	1.1
Total	**88**	**100.0**

COPD: Chronic obstructive pulmonary disease

measured PASP (C: 0.773, p<0.001). Similarly, positive correlations were found between the postoperative PAD measurements and both preoperative echocardiographic PASP (C: 0.513, p<0.001) and catheter-measured PASP (C: 0.575, p<0.001) (Table 3, Figure 2).

Discussion

Pulmonary arterial hypertension (PAH) is defined as a mean PAP exceeding 25 mmHg at rest, a pulmonary capillary wedge pressure of 15 mmHg or less, and a pulmonary vascular resistance greater than 3 Wood units [10]. PAH was first hemodynamically described by Dresdale et al. [11] in 1951, and for decades it remained a disease without an effective treatment. Although significant advances have been made in the medical management of PAH, not all patients respond equally well to pharmacotherapy. For patients who do not respond to optimal vasodilator treatment, lung transplantation is recommended [12]. Improvements in the prognosis of PAH patients have been observed following lung transplantation. Prior to the transplantation era, the survival probability for patients with PH was very low, with an average survival duration of only 2.8 years [13]. However, in high-risk surgical procedures such as lung transplantation, monitoring PAP in both the preoperative and postoperative periods is of great importance.

Traditionally, invasive catheter angiography (ICA) is considered the gold standard for the diagnosis of PAH because it is the only technique that directly measures PASP [1]. Although ICA provides highly accurate results, it is an invasive procedure that carries a risk of complications-such as pneumothorax, bleeding, or infection-in approximately 1% to 5% of cases, making repeating the procedure impractical in every patient [14]. On the other hand, echocardiography, a non-invasive method, serves as a valuable screening tool for the presence of PH, however, it only provides an estimate of the right ventricular systolic pressure. In individual patients, this estimation may be close to the actual pulmonary arterial systolic pressure, or it may be either an overestimation or an underestimation [2,3]. For these reasons, there is a need for alternative non-invasive methods capable of estimating PASP [4].

CT and MR imaging offer significant advantages in addressing these issues due to their cross-sectional and thin-slice imaging capabilities. An MRI study conducted on eight patients with PPH demonstrated that the mean PASP was significantly

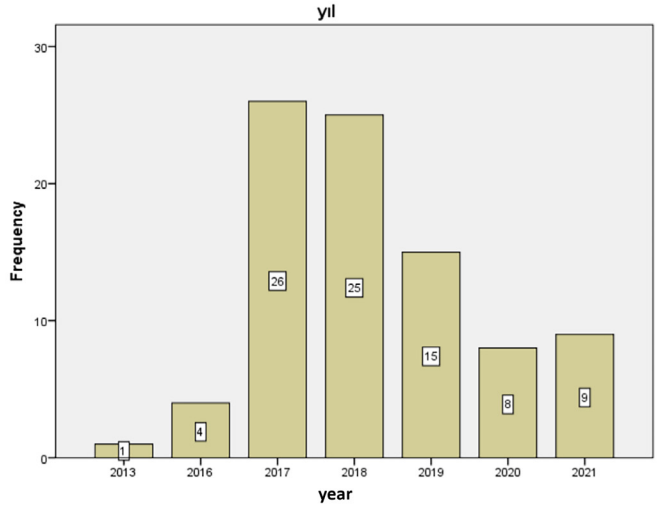

Figure 1. Distribution of lung transplants by year

Table 2. Mean measurements of patients included in the study

Measurement	Mean ± SD	IQR (25th-75th)
Aortic diameter, cm	3.08±0.52	2.70-3.60
Preoperative main pulmonary artery diameter, cm	3.17±0.52	2.70-3.57
Postoperative main pulmonary artery diameter, cm	2.86±0.45	2.70-3.27
PASP measured by echocardiography, mmHg	38.08±12.71	29.25-45.00
PASP measured by catheterization, mmHg	43.44±14.74	34.25-50.75
Tricuspid annular plane systolic excursion	2.38±0.93	1.65-2.80
Pulmonary artery vascular resistance, wood units	2.73±1.60	1.50-3.41

PASP: Pulmonary artery systolic pressure, SD: Standard deviation, IQR: Interquartile range

Table 3. Correlation of preoperative and postoperative pulmonary artery diameter with PASP measurements

	Preoperative main pulmonary artery diameter, cm		Postoperative main pulmonary artery diameter, cm	
	r	p	r	p
PASP measured by echocardiography, mmHg	0.747	<0.001	0.513	<0.001
PASP measured by catheterization, mmHg	0.773	<0.001	0.575	<0.001

r: correlation coefficient (Pearson).

PASP: Pulmonary artery systolic pressure

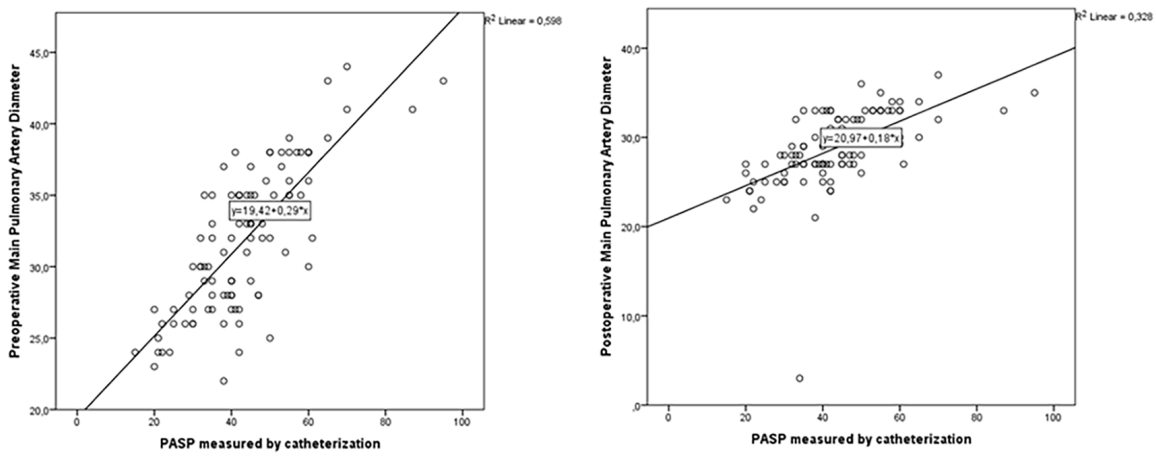

Figure 2. Correlation graph of pre- and postoperative pulmonary artery diameter with PASP measurements

PASP: Pulmonary artery systolic pressure

correlated with the ratio of the mean PAD to the descending thoracic aorta diameter (r=0.7, p<0.01) [5]. However, in cases where the descending thoracic aorta is dilated, this ratio may lose its reliability. Moreover, MRI is more time-consuming, more expensive, and less accessible, making it a less favorable option than CT for this purpose. In addition, the ability of CT to simultaneously evaluate the lung parenchyma is an important advantage [15].

In this study, we aimed to determine whether CT is a reliable method for assessing PAP in patients undergoing lung transplantation. To this end, we evaluated the correlation between the PAD and PASP values measured by ICA and echocardiography.

Our findings indicate that in lung transplant recipients, the measurements of the PAD show a significant correlation with PASP as determined by both invasive and non-invasive methods. Specifically, a strong positive correlation was detected between the main PAD measured in the preoperative period and the PASP measurements obtained via both catheterization and echocardiography (r=0.773 and r=0.747; p<0.001). These results suggest that CT-based measurements may be a reliable method for evaluating PH in the preoperative period.

It has been reported that PAD measurements obtained by CT correlate with certain threshold values for the diagnosis of PH. In long-standing PH, vascular wall calcifications, vascular tortuosity (bending), and the pruning of peripheral branches may be observed. Both tortuosity and fractal dimension have been found to be associated with the severity of PH [16]. Our findings are consistent with previous studies that emphasize the predictive value of PAD derived from CT in the diagnosis of PH.

According to the 2015 European Society of Cardiology/ European Respiratory Society Guidelines for the Diagnosis and Treatment of Pulmonary Hypertension, the presence of a PAD of ≥2.9 cm or a pulmonary artery to ascending aorta diameter ratio of ≥1.0 on CT imaging may increase the suspicion of PH in symptomatic patients [17]. In our study, the mean preoperative PAD was found to be 3.17±0.53 cm, and this value yielded results consistent with PASP measurements. A common feature of PH is the dilation of the central pulmonary arteries. In the study by Tan et al. [18] a main pulmonary artery (MPA) diameter of ≥29 mm was associated with a specificity of 89% and a positive predictive value of 97% in the diagnosis of PH [5]. However, a diameter below this threshold does not completely exclude PH because of the low negative predictive value. When the threshold is raised to 3.2 cm, specificity increases to 93% and the negative predictive value to 90%, although sensitivity drops to 47% [16].

Furthermore, CT provides a comprehensive anatomical evaluation, allowing for the simultaneous assessment of lung parenchymal changes, graft integrity, and post-transplant complications such as bronchial anastomotic stenosis or infection. This comprehensive evaluative capability enhances its clinical utility beyond mere hemodynamic assessment.

In the postoperative period, a significant, yet lower level of correlation between PAD and PASP measurements was observed (r=0.575, p<0.001). The somewhat lower correlation observed in the postoperative period may be attributed to several factors. Postoperative hemodynamic changes-including alterations in vascular compliance, pulmonary vascular remodeling, and graft-related complications-may affect PADs independently of the actual pressure changes. Additionally, immunosuppressive therapy, infections, and other postoperative complications may contribute to vascular changes that do not directly reflect PASP.

The interpretation of an enlarged MPA should be performed with consideration of factors such as interstitial lung disease,

lung fibrosis, and mechanical disruption following lung transplantation. In these patients, traction-related dilation of the MPA may be observed, even in the absence of PAH, and similar dilations can also occur in post-lung transplantation patients [19].

Study Limitations

This study has several limitations. First, it is retrospective in design, with a limited sample size. Additionally, the observation that the correlation values in the postoperative period are lower than those in the preoperative period suggests that the effects of postoperative hemodynamic changes may not be fully elucidated. Therefore, further large-scale prospective studies are warranted.

Conclusion

This study demonstrated that in patients undergoing lung transplantation, the main PAD measured by CT exhibited a significant correlation with PASP measured by invasive catheterization. In particular, CT measurements taken in the preoperative period can be regarded as a reliable non-invasive method for evaluating PAH. This finding represents an important advancement in clinical practice, as it may reduce procedural risks and enhance patient comfort.

Ethics

Ethics Committee Approval: University of Health Sciences Türkiye, Kartal Koşuyolu High Specialization Education and Research Hospital between January 1, 2013, and November 1, 2021. The study was carried out after receiving approval from the Ethics Committee of the relevant institution (decision number: 2021/14/540, date: 19.10.2021).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: N.H., M.E.Ç., Concept: N.H., M.E.Ç., Design: N.H., M.E.Ç., Data Collection or Processing: N.H., M.E.Ç., Analysis or Interpretation: N.H., M.E.Ç., Literature Search: N.H., M.E.Ç., Writing: N.H., M.E.Ç.

Conflict of Interest: No conflict of interest was declared by the authors.

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