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DIAGNOSTIC ACCURACY OF DETECTING PULMONARY HYPERTENSION IN COMPUTED TOMOGRAPHY ON COMPARISON WITH ECHOCARDIOGRAPHY

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Abstract: Pulmonary artery hypertension (PAH) is a significant consequence of various pulmonary and cardiovascular pathologies, often presenting with acute breathlessness. Echocardiography is considered the best non-invasive imaging modality for diagnosing PAH, assessing parameters such as the main pulmonary artery (PA) diameter, right ventricle size, and interventricular septum in the cardiology department. Patients suspected of having underlying causes for PAH are referred to radiodiagnosis, where radiological parameters are computed. This study aims to accurately identify patients with PAH by incorporating detailed patient histories. This one-year observational study was conducted in the Department of Radiodiagnosis at JJM Medical College & Hospital and Chigateri general hospital, Davangere, including 143 patients. These patients underwent both echocardiography and computed tomography (CT). Parameters such as the main pulmonary artery to aorta diameter ratio, right ventricular size, and interventricular septum were assessed. These parameters were initially evaluated using echocardiography and further analyzed using CT pulmonary angiography with a 50-slice GE Evolution scanner. Sensitivity, specificity, and predictive values were calculated for CT and compared with echocardiography. The study population had a mean age of 57.02 ± 16.20 years, with ages ranging from 18 to 99 years. There were 75 males and 68 females. The most common symptom was breathlessness (44.76%), followed by palpitations (25.27%). The sensitivity and specificity of detecting PAH in CT with the main pulmonary artery diameter to aorta ratio >1 was 67.1% and 98.5%, respectively, with positive and negative predictive values of 98.0% and 74.1%, and a diagnostic accuracy of 82.5%. The sensitivity and specificity of detecting PAH in CT with right ventricular dilatation were 56.25% and 83.0%, respectively, with positive and negative predictive values of 31.0% and 85.9%, and a diagnostic accuracy of 74.8%. For interventricular septum bowing, the sensitivity and specificity were 60.0% and 8.6%, respectively, with positive and negative predictive values of 20.0% and 98.4%, and a diagnostic accuracy of 90.2%. In conclusion, CT parameters for PAH, such as the main pulmonary artery to aorta ratio, showed high specificity and positive predictive value, with an accuracy of 82.5%. Right ventricular dilatation had moderate specificity and negative predictive value with an accuracy of 74.2%. Interventricular septum bowing in CT demonstrated high negative predictive value with an accuracy of 90.2%.

1. Introduction

Pulmonary artery hypertension (PAH) is a severe and progressive condition characterized by elevated pressure in the pulmonary arteries, resulting in significant morbidity and mortality. It is frequently associated with various cardiovascular and pulmonary diseases and can lead to right ventricular failure and, ultimately, death if left untreated. Early and accurate diagnosis is crucial for effective management and improving patient outcomes [1].

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PAH arises when the pulmonary arteries constrict or become obstructed, leading to increased vascular resistance. This heightened resistance forces the right ventricle to exert more effort to pump blood through the lungs, eventually causing right ventricular hypertrophy and heart failure. The causes of PAH are diverse, ranging from idiopathic origins to secondary conditions such as chronic obstructive pulmonary disease (COPD), interstitial lung disease, congenital heart defects, and thromboembolic disorders [2].

Timely diagnosis of PAH is essential because it allows for early intervention, which can slow disease progression, alleviate symptoms, and improve the patient's quality of life. However, the non-specific nature of PAH symptoms, such as breathlessness, fatigue, and palpitations, often leads to delayed diagnosis and treatment. Consequently, reliable diagnostic tools are indispensable for the early detection of this condition [3].

Right heart catheterization is the gold standard for diagnosing PAH, providing direct measurement of pulmonary artery pressures. However, this invasive procedure carries inherent risks and may not be suitable for all patients. Therefore, non-invasive imaging modalities like echocardiography and computed tomography (CT) are critical in the diagnostic workup of PAH.

Transthoracic echocardiography (TTE) is widely regarded as the standard non-invasive imaging tool for diagnosing PAH. It evaluates right ventricular size and function, estimates pulmonary artery pressures, and assesses other cardiac abnormalities. Echocardiography is favoured for its accessibility, cost-effectiveness, and comprehensive cardiac assessment capabilities. Studies have shown that TTE has a sensitivity of 83% and specificity of 72% for diagnosing PAH.

Computed tomography pulmonary angiography (CTPA) is another valuable non-invasive imaging modality used to diagnose PAH. CTPA provides detailed visualization of the pulmonary arteries and their anatomy, making it particularly useful for identifying pulmonary thromboembolism, a common cause of PAH. Advances in CT technology, such as the 50-slice CT scanner, have improved imaging resolution and accuracy, enhancing its reliability for assessing pulmonary vascular diseases [4].

Despite the widespread use of echocardiography and CT in diagnosing PAH, there is limited comparative research on their diagnostic accuracy within the same patient population. This gap in the literature highlights the need for studies evaluating the effectiveness of these imaging modalities side-by-side. Understanding their relative strengths and limitations can inform clinical decision-making and optimize diagnostic strategies for PAH.

This study aims to determine the diagnostic accuracy of detecting pulmonary hypertension using computed tomography (CT) compared with echocardiography. By assessing the sensitivity and specificity of CT in identifying PAH and comparing these parameters with those obtained from echocardiography, this research seeks to provide valuable insights into the diagnostic performance of these imaging modalities. The findings can guide clinicians in selecting the most appropriate imaging technique for diagnosing PAH, ultimately improving patient management and outcomes.

Conducted at JJM Medical College &Hospital and Chigateri general hospital, Davangere, this study involved 143 patients with suspected PAH evaluated using both echocardiography and CT over one year. The comprehensive approach and utilization of advanced imaging technology underscore the study's relevance and potential impact on clinical practice

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2. Methods

Source of Data

The data for this study were sourced from patients with clinical suspicion of pulmonary hypertension who presented to the Department of Radio-Diagnosis at JJM Medical College &Hospital and Chigateri general hospital, Davangere

Study Design

This study was designed as a prospective, observational study.

Sample Size

The study comprised 143 patients. The sample size was calculated using the following formula based on the prevalence rate:

n=zα2P(1−P) d2n = \frac{z_{\alpha} ^2 P (1 - P)}{d^2}n=d2zα2P(1−P)

Where:

- PPP is the prevalence percentage,
- ddd is the percentage difference in prevalence,
- zαz_{\alpha} zα corresponds to the level of significance.

For a 5% significance level, zα=1.96z_{\alpha} = 1.96zα=1.96. With P=30%P = 30\%P=30% and d=7.5%d = 7.5\%d=7.5%, the sample size was determined to be 143.

Inclusion Criteria

Patients clinically suspected of having pulmonary hypertension, who were evaluated with echocardiography and subsequently subjected to CT, presenting with symptoms for four weeks or more, including:

- Shortness of breath
- Palpitations
- Chest pain
- Swelling of lower limbs
- Cough

Exclusion Criteria

- Pregnant women (due to the contraindication for radiation exposure).

Data Collection

Data were collected from patients with clinical suspicion of pulmonary hypertension who underwent echocardiography in the cardiology department and were referred to the radiology department for CT studies. The echocardiography evaluated parameters such as the main pulmonary artery (PA) diameter, right ventricular size, and interventricular septum bowing.

Patients were then subjected to CT pulmonary angiography using a 50-slice GE Evolution machine with Omnipaque contrast material (70-90 ml) to diagnose pulmonary hypertension. A standard scan protocol was followed for all patients undergoing computed tomography.

Parameters Assessed

The following parameters were assessed for diagnosing pulmonary hypertension:

- Main pulmonary artery to aorta diameter ratio
- Right ventricular size
- Interventricular septum bowing

Diagnostic Procedures

1. **Echocardiography:**
    - Conducted in the cardiology department to initially assess the parameters for pulmonary hypertension.

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- Evaluated the main pulmonary artery diameter, right ventricular size, and interventricular septum bowing.

2. **Computed Tomography Pulmonary Angiography (CTPA):**
   - Performed using a 50-slice GE Evolution machine with Omnipaque contrast material (70-90 ml).
   - Parameters such as the main pulmonary artery to aorta diameter ratio, right ventricular size, and interventricular septum bowing were reassessed.
   - Findings from the CT were recorded and compared with those from echocardiography.

Statistical Analysis

The collected data were statistically analyzed to determine the diagnostic accuracy of computed tomography in comparison with echocardiography for detecting pulmonary hypertension. The statistical analysis included:

1. **Descriptive Statistics:**
   - Mean and standard deviation were used to summarize continuous variables.
   - Discrete variables were represented by median values.
2. **Sensitivity and Specificity Analysis:**
   - Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of CT parameters were calculated and compared with echocardiography.
3. **Comparative Statistics:**
   - The student's unpaired t-test was used for comparing continuous variables between two groups.
   - Chi-square test, test of proportion, or Fisher's exact test was used for assessing associations between clinical and demographic characteristics and outcomes.
4. **Significance Testing:**
   - A p-value < 0.05 was considered statistically significant in all analyses.
5. **Graphical Representation:**
   - Suitable graphs, such as bar charts and scatter plots, were used to visually depict comparisons and diagnostic performance.

This comprehensive approach ensured a thorough evaluation of the diagnostic accuracy of computed tomography in comparison with echocardiography, providing valuable insights into the effectiveness of these imaging modalities for detecting pulmonary hypertension

3. Results

Age-wise Distribution of Cases

In this study population, the mean age was 57.02 ± 16.20 years. The age distribution showed that a small portion of the participants, 10 cases (6.99%), were aged 30 years or younger. There were 14 cases (9.79%) aged between 31 to 40 years. A more significant number of participants, 23 cases (16.08%), were between the ages of 41 to 50 years. The age group of 51 to 60 years had the highest number of cases, with 33 participants (23.08%). Those aged 61 to 70 years comprised 31 cases (21.68%), and the group aged 71 years and older included 32 cases (22.38%).

Gender-wise Distribution of Cases

Among the study population, there was a slight predominance of male participants, with 75 males (52.45%) compared to 68 females (47.55%). This nearly equal distribution highlights that pulmonary hypertension affects both genders relatively equally in this sample.

Clinical Symptoms in the Study Population

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The most common clinical symptom among the study population was breathlessness, reported by 64 cases (44.76%). This was followed by a combination of breathlessness and cough, which was noted in 36 cases (25.17%). Palpitations were also a significant symptom, present in 36 cases (25.17%). A smaller number of participants presented with breathlessness and cough with a history of road traffic accidents (RTA), accounting for 4 cases (2.80%), and breathlessness with a history of RTA in 2 cases (1.40%).

Duration of Symptoms

The majority of the study population, 134 cases (93.71%), reported acute symptoms, while 9 cases (6.29%) experienced acute on chronic symptoms. This indicates that most patients presented with sudden onset symptoms rather than prolonged or recurrent episodes.

Associated Co-morbidities

Among the study population, 44 cases (30.77%) did not have any associated comorbidities. However, a significant number of cases were associated with hypertension (33 cases, 23.08%) and ischemic heart disease (30 cases, 20.98%). Diabetes mellitus was present in 23 cases (16.08%). Other combinations of comorbidities included diabetes mellitus with a history of ischemic heart disease (1 case, 0.70%) and diabetes mellitus and hypertension with a history of ischemic heart disease (1 case, 0.70%). There was also one case associated with a previous history of congenital heart disease (0.70%).

ECHO Findings of Pulmonary Artery Hypertension

Echocardiography findings indicated that 73 cases (51.05%) had a pulmonary artery to aorta ratio greater than 1, suggesting pulmonary hypertension. Right ventricular dilatation was observed in 25 cases (17.48%), and bowing of the interventricular septum was present in 5 cases (3.50%).

CT Findings of Pulmonary Artery Hypertension

Computed tomography findings showed that 49 cases (34.27%) had an increased pulmonary artery to aorta ratio diameter. Right ventricular dilatation was noted in 29 cases (20.28%), and interventricular septum bowing was present in 15 cases (10.49%). Additionally, the right pulmonary artery diameter exceeded 16 mm in 34 cases (23.78%), and the left pulmonary artery diameter exceeded 16 mm in 28 cases (19.58%).

Sensitivity and Specificity Analysis

The sensitivity and specificity of detecting pulmonary artery hypertension with an increased diameter of the main pulmonary artery to aorta ratio greater than 1 using CT over echocardiography were found to be 67.10% and 98.5%, respectively. The positive predictive value (PPV) was 98.0%, the negative predictive value (NPV) was 74.1%, and the overall diagnostic accuracy was 82.5%.

For the assessment of right ventricular dilatation using CT compared to echocardiography, the sensitivity was 56.25%, specificity was 83.0%, PPV was 31.0%, NPV was 85.9%, and diagnostic accuracy was 74.8%.

The sensitivity and specificity for the assessment of bowing of the interventricular septum using CT compared to echocardiography were lower, with sensitivity at 60.0% and specificity at 8.6%. The PPV was 20.0%, NPV was 98.4%, and diagnostic accuracy was 90.2%.

Comparison of ECHO and CT in the Assessment of Pulmonary Artery: Aorta Ratio

The study revealed that 73 cases (51.05%) had a pulmonary artery to aorta ratio greater than 1 as detected by echocardiography, whereas only 49 cases (34.27%) were identified by CT. The comparison using McNemar's test yielded a significant p-value of 0.0050, indicating a statistically significant difference between the two modalities.

Comparison of ECHO and CT in the Assessment of Right Ventricular Dilatation

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Echocardiography identified right ventricular dilatation in 25 cases (17.48%), while CT detected it in 28 cases (19.58%). The comparison showed no significant difference between the two modalities, with a McNemar's test p-value of 0.7550.

Comparison of ECHO and CT in the Assessment of Interventricular Septum Bowing

Echocardiography detected bowing of the interventricular septum in 5 cases (3.50%), whereas CT detected it in 15 cases (10.49%). The comparison showed a significant difference, with a McNemar's test p-value of 0.0310.

Detection of Pulmonary Thromboembolism

Pulmonary thromboembolism was identified in 6 cases (4.2%) using echocardiography, compared to 15 cases (10.49%) detected by CT. This indicates a higher detection rate of pulmonary thromboembolism with CT.

Pulmonary Hypertension in COPD Patients

Among the 143 patients, 28 (19.5%) had chronic obstructive pulmonary disease (COPD). Out of these, 15 patients (53.5%) were found to have pulmonary hypertension on CT, while 13 patients (46.5%) did not show evidence of pulmonary hypertension. This highlights the prevalence of pulmonary hypertension in COPD patients detected through CT

Table 1: Demographic and Clinical Symptoms

Parameter	**Number of Cases**	**Percentage (%)**
Age Distribution		
Age <= 30 years	10	6.99
Age 31-40 years	14	9.79
Age 41-50 years	23	16.08
Age 51-60 years	33	23.08
Age 61-70 years	31	21.68
Age >= 71 years	32	22.38
Gender Distribution		
Male	75	52.45
Female	68	47.55
Clinical Symptoms		
Breathlessness	64	44.76
Cough	1	0.70
Breathlessness with chest pain	36	25.17
Breathlessness and Cough with history of RTA	4	2.80
Breathlessness with history of RTA	2	1.40
Palpitations	36	25.17

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Duration of Symptoms		
Acute	134	93.71
Acute on chronic	9	6.29

Table 2: Associated Co-morbidities and Pulmonary Thromboembolism

Parameter	**Number of Cases**	**Percentage (%)**
Associated Co-morbidities		
Diabetes mellitus	23	16.08
Diabetes mellitus with old h/o ischemic heart disease	1	0.70
Diabetes mellitus and Hypertension with old h/o ischemic heart disease	1	0.70
Hypertension	33	23.08
Hypertension with old h/o ischemic heart disease	10	6.99
H/o ischemic heart disease	30	20.98
Associated with previous history of congenital heart disease	1	0.70
Nil	44	30.77
Pulmonary Thromboembolism Detection		
ECHO Detection	6	4.20
CT Detection	15	10.49

Table 3: ECHO and CT Findings

Parameter	**Number of Cases**	**Percentage (%)**
ECHO Findings		
Pulmonary artery: aorta ratio > 1	73	51.05
RV dilatation	25	17.48
Bowing of the interventricular septum	5	3.50
CT Findings		
Pulmonary artery: aorta ratio > 1	49	34.27
Right PA diameter > 16mm	34	23.78

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Left PA diameter > 16mm	28	19.58
RV dilatation	29	20.28
Interventricular septum bowing	15	10.49
COPD Patients with Pulmonary Hypertension		
COPD patients with pulmonary hypertension	15	53.5

CASE 1: 40 yr old male came with history of breathlessness

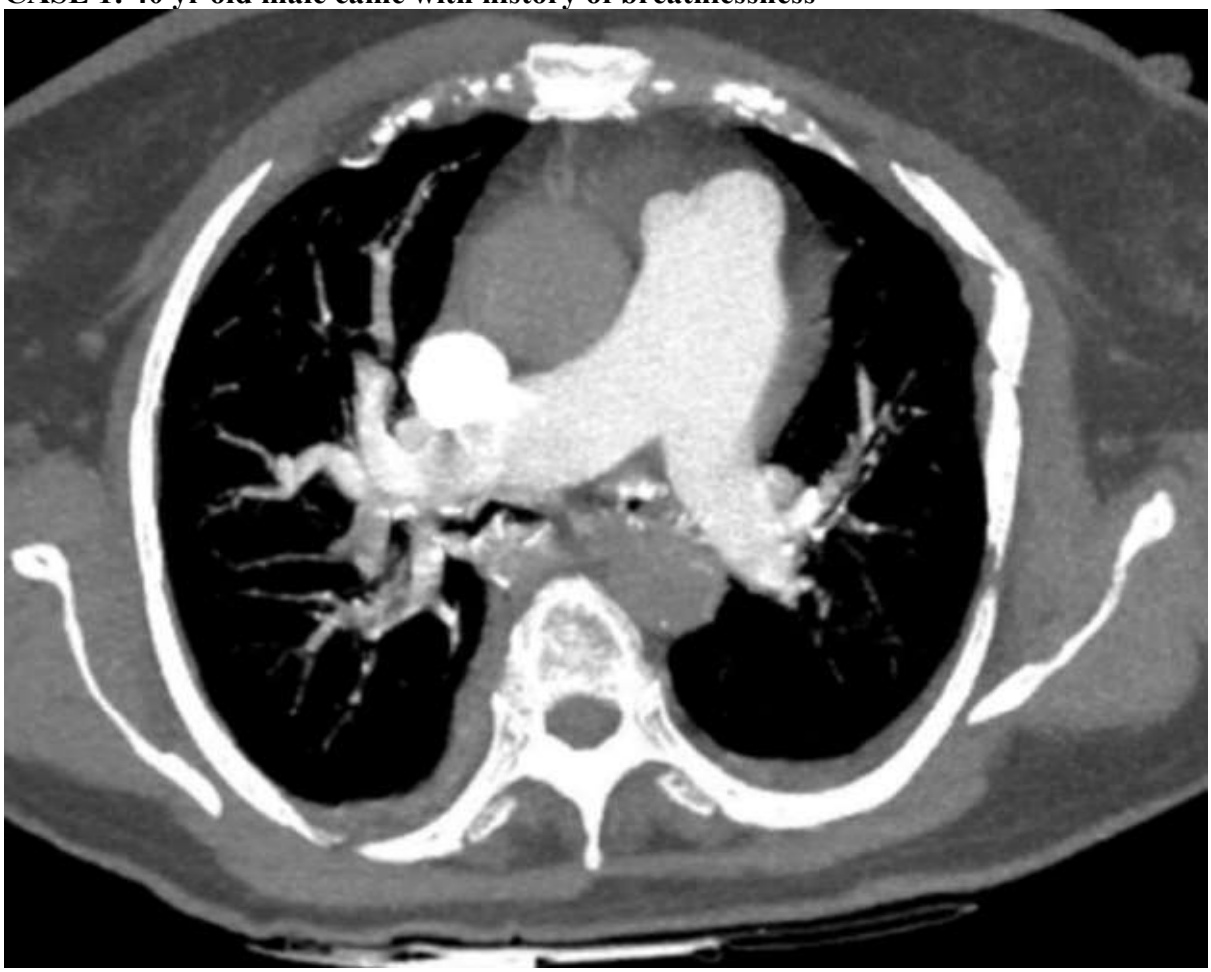

Figure 1: CTPA in axial section showing evidence of increased diameter of MPA to aorta ratio associated with bilateral minimal pleural effusion

CASE 2: 45 yr old female with palpitations and chest pain. in a

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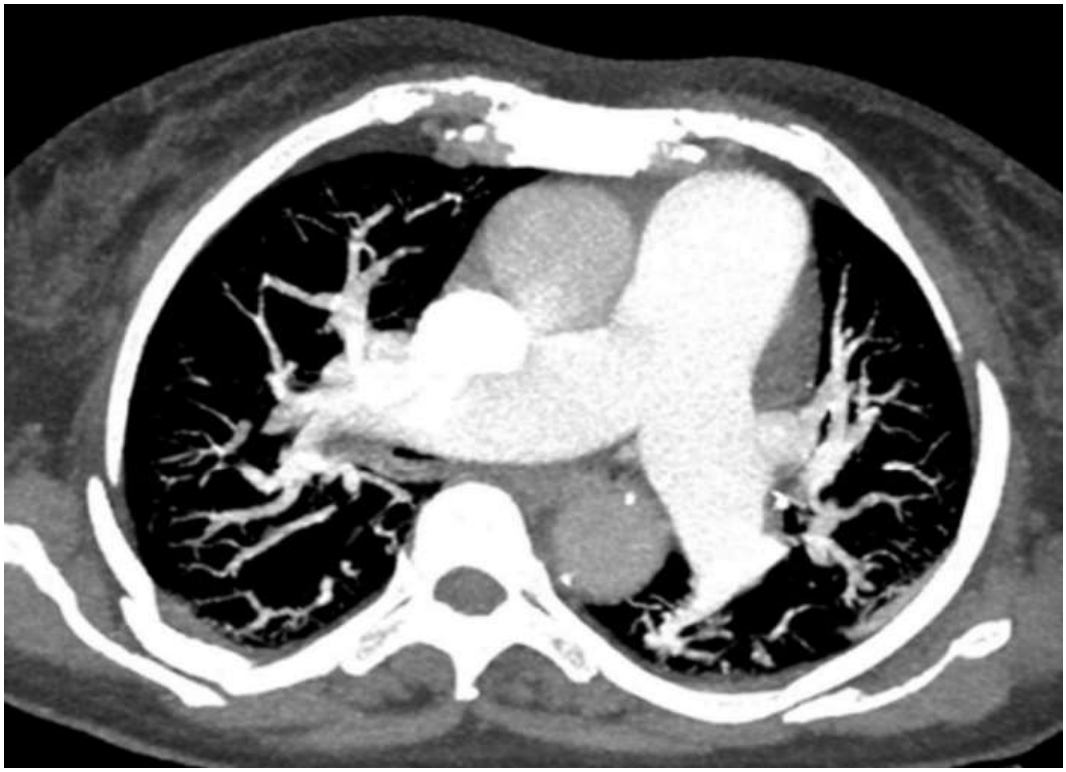

Figure 2. CTPA (maximum intensity projection image) in axial section showing evidence of increased diameter of MPA: aorta.

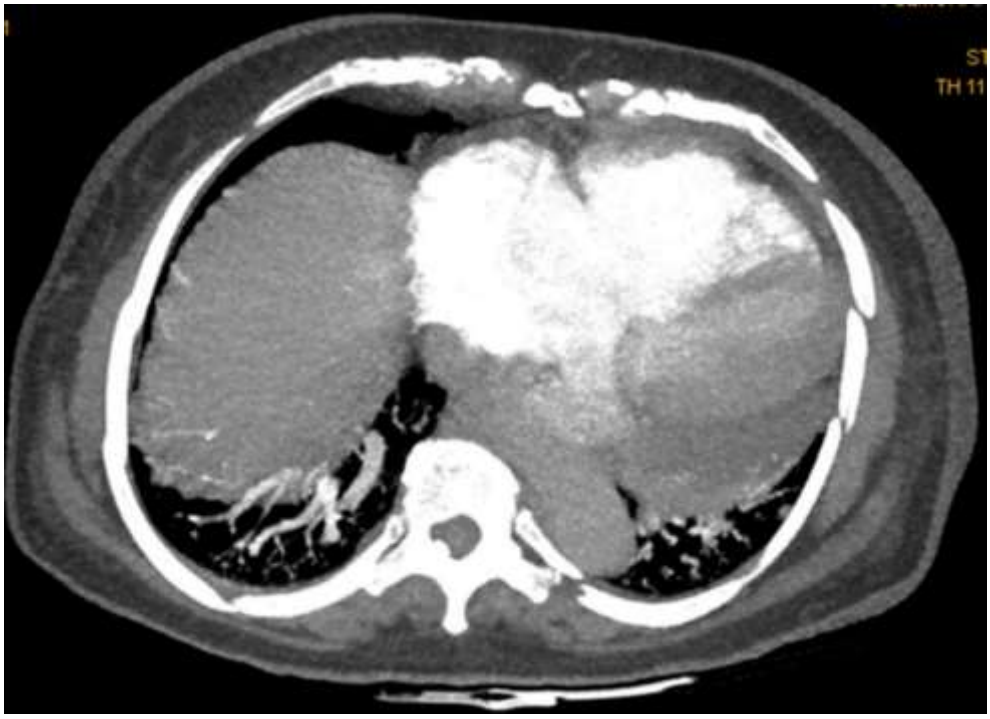

Figure 3: CTPA (maximum intensity projection image) in axial section showing dilatation of right ventricle.

CASE 3: 51 YR OLD FEMALE WITH ACUTE ONSET OF BREATHLESSNESS

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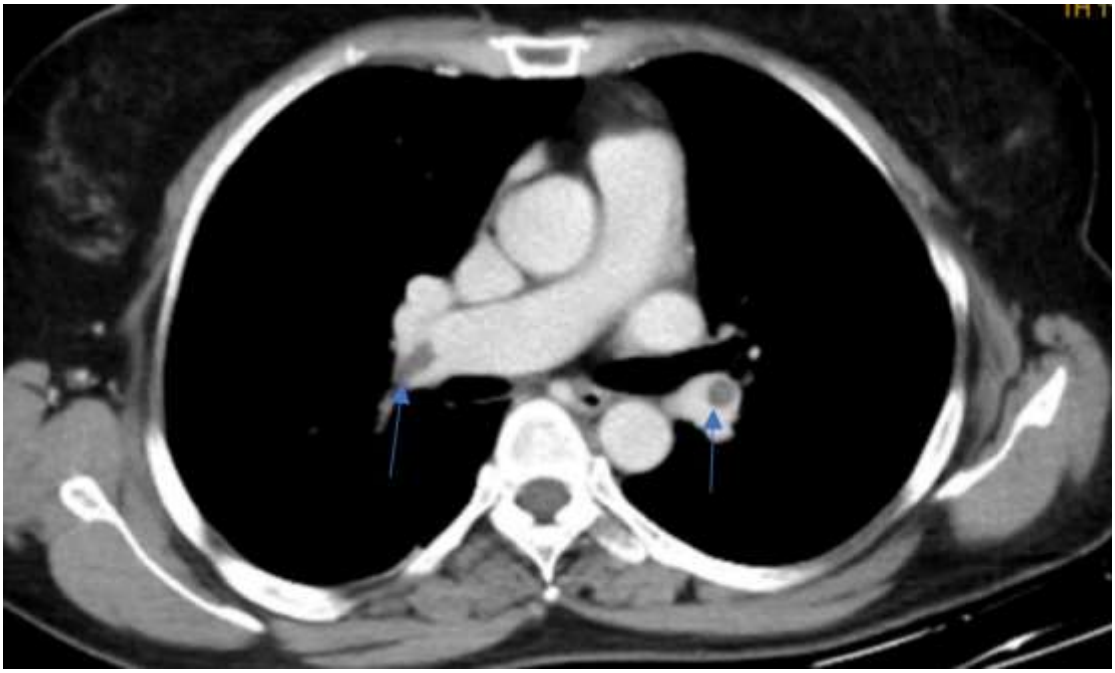

Figure 4: CTPA in axial section showing thrombus in the right and left pulmonary artery with normal MPA to aorta ratio

CASE 4: 40 yr male came with complaints of breathlessness with history of chronic smoking

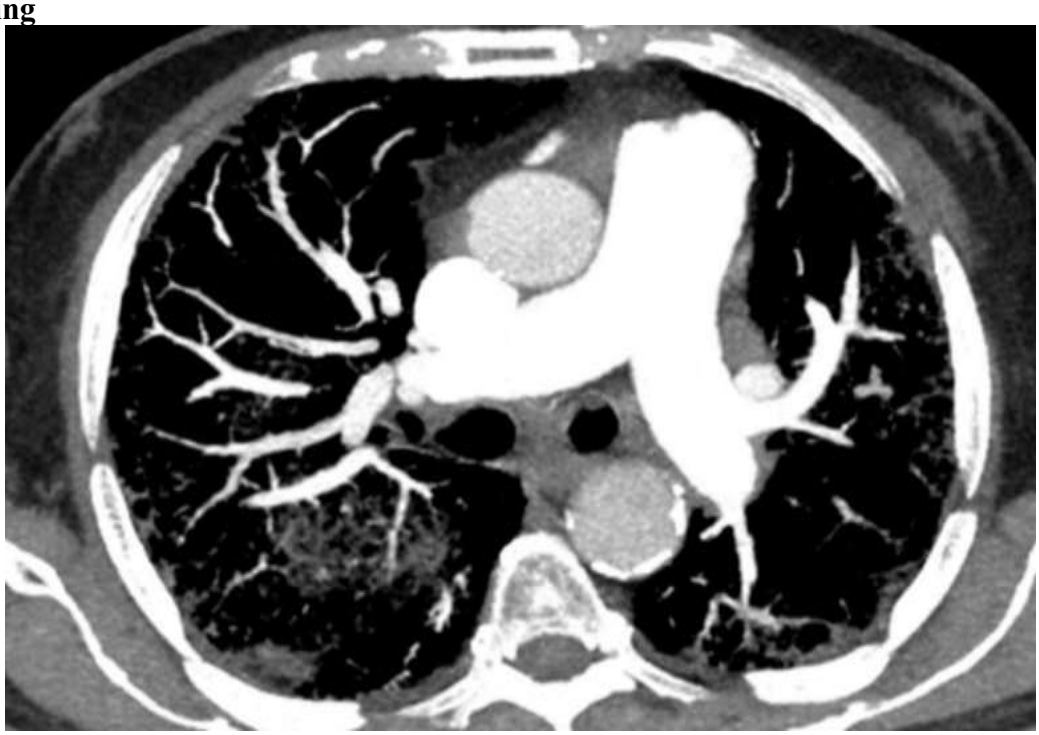

Figure 4: CTPA in axial section showing evidence of dilated MPA with increased MPA: aorta diameter ratio

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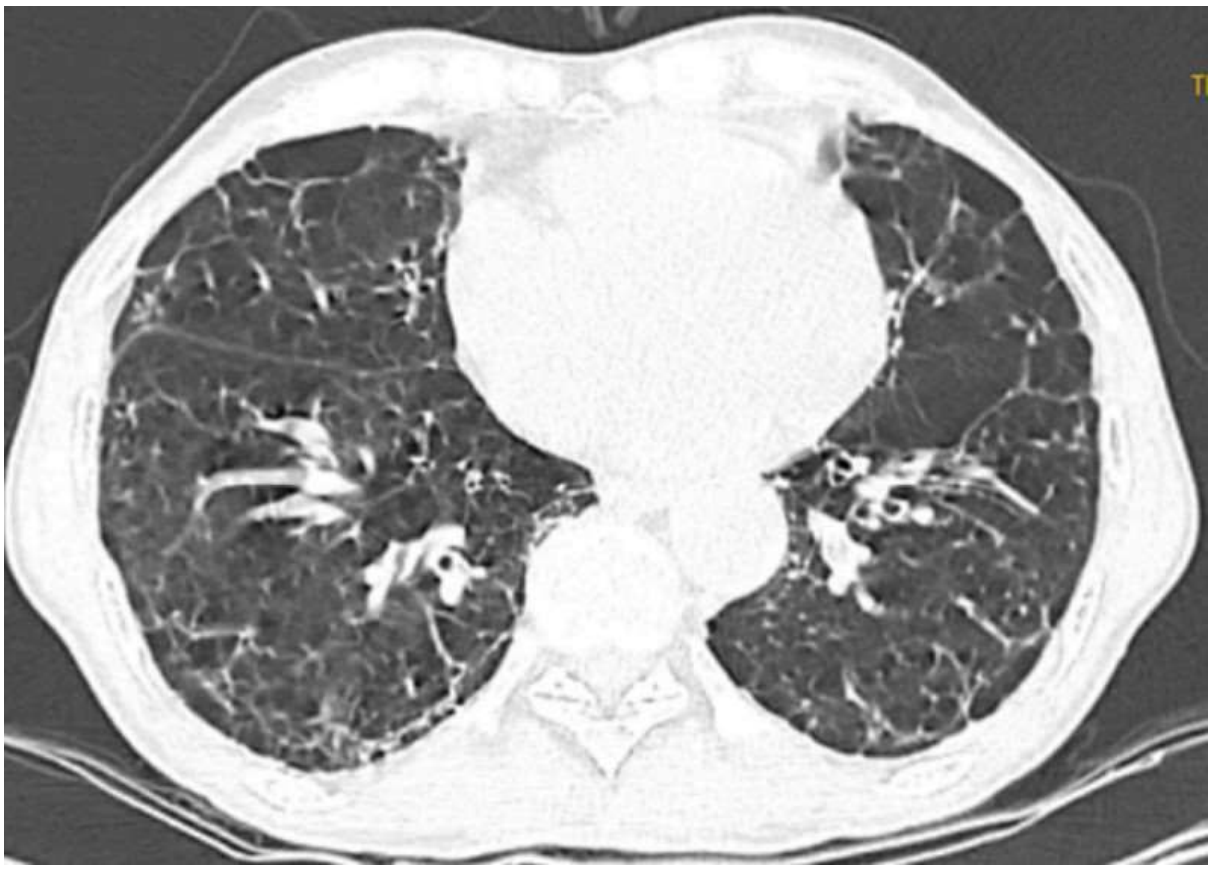

Figure 5: CTPA in axial section showing COPD changes in the bilateral lung parenchyma.

4. Discussion

This study aimed to evaluate the diagnostic accuracy of detecting pulmonary hypertension using computed tomography (CT) in comparison with echocardiography (ECHO). By examining detailed clinical histories, the acuity of symptoms, and associated comorbidities, we gained valuable insights into the utility of these imaging modalities.

The mean age of the participants was 57.02 ± 16.20 years, aligning with similar studies such as that by Orem et al., where the mean age was 50 ± 14 years. The most common symptom observed was breathlessness, present in 64 patients (44.76%), followed by palpitations in 36 patients (25.17%). These findings are consistent with studies by Schwanwell et al. and Dunlap et al., which reported exertional dyspnea and angina as predominant symptoms, respectively [5,6].

Echocardiography is widely regarded as the standard non-invasive imaging modality for diagnosing pulmonary hypertension, typically assessed by measuring the mean pulmonary artery pressure (mPAP). However, CT parameters such as the pulmonary artery to aorta (PA) ratio, right ventricular dilatation, and interventricular septum bowing offer additional diagnostic value. In this study, ECHO detected an increased PA ratio > 1 in 73 patients (51.05%), whereas CT identified this parameter in 49 patients (34.27%), with a sensitivity of 67.1%, specificity of 98.5%, and an accuracy of 82.5%. This was supported by Shen et al., who found a sensitivity of 79% and specificity of 74% for similar parameters on CT.

The detection of right ventricular dilatation by ECHO and CT showed comparable results, with CT demonstrating a sensitivity of 56.25%, specificity of 83.0%, and an accuracy of 74.8%. No

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significant statistical difference was observed between ECHO and CT for this parameter (p-value = 0.75). However, the assessment of interventricular septum bowing showed a significant difference, with CT detecting this feature in 15 cases compared to 5 cases by ECHO, highlighting CT's higher negative predictive value of 98.4% and diagnostic accuracy of 90.2%. CT also showed a superior ability to detect pulmonary thromboembolism, identifying it in 15 cases (10.49%) compared to 6 cases (4.2%) by ECHO. This higher sensitivity of CT over ECHO for detecting pulmonary thromboembolism is consistent with findings by Grifoni et al. and Moore et al., which demonstrated high sensitivity and specificity of CT pulmonary angiography (CTPA) [7].

Additionally, CT was effective in assessing pulmonary hypertension in patients with chronic obstructive pulmonary disease (COPD), identifying it in 15 out of 28 COPD patients (53.5%). Studies by Iliaz et al. and Cuttica et al. corroborate these findings, emphasizing the association between increased PA [8,9] ratio and right ventricular changes in COPD patients, which can indicate early or mild pulmonary hypertension.

Overall, this study highlights the significant diagnostic value of CT in detecting pulmonary hypertension and its associated conditions, offering a comprehensive evaluation of both pulmonary and cardiac pathologies.

5. Conclusion

Pulmonary artery hypertension can be accurately assessed using both echocardiography and computed tomography, with ECHO being the standard non-invasive imaging investigation. The most common clinical symptom observed was breathlessness, followed by palpitations. In comparison to ECHO, CT demonstrated high specificity and positive predictive value for increased pulmonary artery to aorta ratio >1, moderate specificity for right ventricular dilatation, and high negative predictive value for interventricular septum bowing. CT also showed superior sensitivity in detecting pulmonary thromboembolism and was effective in evaluating pulmonary hypertension in COPD patients. These findings suggest that while ECHO remains crucial, CT provides a comprehensive diagnostic advantage, particularly for detecting underlying causes and associated pathologies in pulmonary hypertension.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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