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Original Article

Radiology Section

Comparison of CT-Determined Pulmonary Artery Diameter among Smokers and Non-smokers: A Cross-sectional Study

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ABSTRACT

Introduction: Tobacco smoking is a common addiction in our society. The toxic chemical compounds present in tobacco smoke cause epithelial damage and inflammation of the airways. Chronic smoking results in the thickening of the pulmonary arterial wall and vasoconstriction, leading to the development of pulmonary arterial hypertension. Hence, measurement of pulmonary artery diameter using Contrast Enhanced Computed Tomography (CECT) may be helpful in the early detection of pulmonary arterial hypertension.

Aim: To compare the diameters of the Main Pulmonary Artery (MPA), Right Pulmonary Artery (RPA), and Left Pulmonary Artery (LPA) using CECT thorax in smokers and non-smokers.

Materials and Methods: A cross-sectional study was conducted from April 2021 to March 2022 in the department of radio-diagnosis, KS Hegde Hospital, Karnataka, India, consisting of 100 patients referred for CECT thorax in the age group of 18-85 years. They were divided into two groups: smokers and non-smokers, with 50 patients in each group. They were further categorised into three age groups: < 50 years, 50-60 years, and >60 years. The widest diameters of the MPA were measured at the level of bifurcation of the artery and perpendicular to the long axis of the artery. At this level, RPA and LPA diameters were measured at the widest portion on 1.25 mm axial images of the arterial phase. Variation in the pulmonary artery diameter was compared between smokers and non-smokers with respect to age and analysed by unpaired t-test and Pearson correlation.

Results: Diameters of MPA, RPA, and LPA were statistically significant ($p<0.05$) in smokers compared to non-smokers. In smokers, MPA and RPA diameters correlated with age, which was statistically significant ($p<0.05$). No significant correlation ($p>0.05$) was shown between age and MPA, RPA, and LPA diameter in non-smokers. The mean MPA diameter showed a significant difference ($p<0.05$) in all three age groups.

Conclusion: The diameter of the pulmonary artery is statistically significant in smokers compared to non-smokers. Hence, assessment of pulmonary artery diameters among smokers using CECT thorax will help to diagnose Pulmonary Hypertension (PH) at an early stage.

Keywords: Contrast enhanced computed tomography, Left pulmonary artery, Main pulmonary artery, Pulmonary hypertension, Right pulmonary artery

INTRODUCTION

The lungs play an essential role in the exchange of gases. Their primary function is to supply oxygen to the blood and remove carbon dioxide from the blood. There are three levels of barriers that protect the lungs from harmful chemicals. The nose serves as the first barrier system, consisting of cilia and hair follicles, which does not allow large particles from entering. The second barrier is coughing, which helps remove any inhaled particles. The third barrier consists of the epithelial lining on the surface of the airway, which helps prevent infections [1].

One of the common addictions in our society is smoking. Smoking consists of toxic chemical compounds that are carcinogenic and cause epithelial damage and inflammation of the airways [2]. Lung damage increases with the number of cigarettes smoked [3]. Smokers' life expectancy is 14 years lower compared to non-smokers [4]. Developing countries show higher rates of cancer and patient deaths related to smoking compared to developed countries. Tobacco smoking is one of the leading causes of death in developing countries [5].

Smoking leads to airway inflammation and thickening of the pulmonary arterial wall [6]. Some studies have shown that tobacco smoke causes elevated expressions of the vascular endothelial growth factor and suppresses the endothelial nitric oxide synthase in the pulmonary artery [7,8]. This leads to an increase in circulating endothelin, leading to pulmonary arterial vasoconstriction and PH [9,10].

Examination and visualisation of the pulmonary artery can be performed using various non-invasive imaging techniques such as chest radiography, Magnetic Resonance Imaging (MRI), and Computed Tomography (CT). Pulmonary artery enlargement may be caused by PH, leading to right heart failure and enlargement. Patients with lung diseases may exhibit enlarged pulmonary arteries [11,12]. Pulmonary artery enlargement can be visualised in a chest X-ray. However, CT and MRI play a vital role in measuring pulmonary artery size, as there is no overlap with mediastinal and hilar organs [13]. In PH, the mean pulmonary artery pressure is more than 25 mm Hg at rest and more than 30 mm Hg during exercise. If the pulmonary artery diameter is more than 29 mm in a CT scan, it may indicate PH [14].

In this study, the author aimed to address the assessment of pulmonary artery diameters among smokers using CECT thorax. This study will be helpful in diagnosing PH at an early stage by comparing the diameters of the MPA, RPA, and LPA on CECT thorax in smokers and non-smokers.

MATERIALS AND METHODS

A cross-sectional study was conducted from April 2021 to March 2022 in the Department of Radiodiagnosis at Justice KS Hegde Charitable Hospital, Mangalore, Karnataka, India. The study was approved by the Institutional Ethical Committee (INST.EC/EC/101/2021-22). It included a total of 100 patients aged between 18 and 85 years who were referred for a CECT thorax scan.

Sample size calculation: A random sampling method was used. At a 5% level of significance and 80% power, the required sample size per group was 50. Patients who were currently active smokers

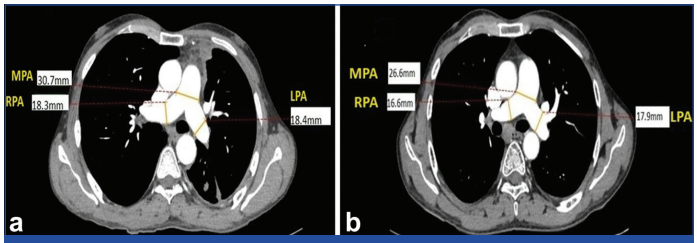
and had a smoking history of minimum one year were categorised as smokers. Individuals who had never smoked were categorised as non-smokers. They were further categorised into three age groups: <50 years, 50-60 years, and >60 years.

Inclusion criteria: Those patients aged between 18 and 85 years with a smoking history of minimum one year were included in the study.

Exclusion criteria: Those Patients with structural cardiac diseases, diagnosed cases of PH, pulmonary thromboembolism, and lung fibrosis due to various reasons were excluded from the study.

Procedure

Scans were performed on the GE Revolution Evo (128-slice multidetector CT). Non-ionic iodinated contrast of 60-80 mL was given intravenously at a flow rate of 3 mL per second. Routine scan parameters including cranio-caudal scan direction, 5 mm slice thickness, and 5 mm slice increment were maintained for each scan. The diameters of the MPA, RPA, and LPA were measured separately in all three groups, including smokers and non-smokers [Table/Fig-1]. The widest diameter of the MPA was measured at the level of the artery's bifurcation and perpendicular to the artery's long axis. At this level, the RPA and LPA appeared to be of equal sizes. The diameters of the RPA and LPA were measured at their widest portions on 1.25 mm axial images of the arterial phase. All measurements were conducted using the reformat tools of the CT machine.



[Table/Fig-1]: a) MPA, RPA and LPA diameter measurement on smokers; b) MPA, RPA and LPA diameter measurement on non-smokers.

STATISTICAL ANALYSIS

The variation in pulmonary artery diameter was compared between smokers and non-smokers with respect to age and analysed using an unpaired t-test and Pearson correlation. The data were expressed as mean ± standard deviation. A p-value <0.05 was considered statistically significant. The Pearson correlation coefficients was used to assess the correlation of MPA, RPA, and LPA diameters with age in both smokers and non-smokers. The statistical analysis was conducted using Statistical Package for Social Sciences (SPSS) software version 2.0.

RESULTS

In this study, 100 patients were included and all were males. An unpaired t-test was used to compare the mean age between smokers and non-smokers, revealing a mean age in smokers of 58.74±12.565 mm and 53.54±14.442 mm in non-smokers. No significant difference (p>0.05) was found in mean age between smokers and non-smokers. However, a significant difference was noted in MPA diameter in smokers and non-smokers with p<0.001. The mean LPA diameter in the smokers and non-smokers group was 17.5200±3.54585 mm and 15.7920±1.96716 mm, respectively, with a significant difference noted in LPA diameter in smokers and non-smokers with p<0.05 [Table/Fig-2].

The comparison of pulmonary artery diameters in smokers and non-smokers under each age group was done by unpaired t-test. In the age group of <50 years, which included 10 patients in the smokers group and 17 patients in the non-smokers group, a significant difference (p<0.05) was observed in mean MPA diameter, RPA diameter, and LPA diameter [Table/Fig-3].

Parameters	Groups	Mean (mm)	SD (mm)	Mean difference (mm)	t-value	p-value
Age (18-85 years)	Smokers	58.74	12.57		1.921	0.58
	Non-smokers	53.54	14.44			
MPA diameter	Smokers	31.906	4.5259	6.166	8.308	**<0.001**
	Non-smokers	25.74	2.6562			
RPA diameter	Smokers	18.028	4.0156	3.200	4.77	**<0.001**
	Non-smokers	14.83	2.5256			
LPA diameter	Smokers	17.5200	3.54585	1.72800	3.013	**0.004**
	Non-smokers	15.7920	1.96716			

[Table/Fig-2]: Comparison of pulmonary artery diameters in smokers and non-smokers.

Parameters	Age (<50 years)	Mean (mm)	SD (mm)	t-value	p-value
MPA diameter	Smokers	29.33	2.3481	4.196	**0.001**
	Non-smokers	25.612	1.9934		
RPA diameter	Smokers	16.84	1.8075	2.749	**0.011**
	Non-smokers	14.429	2.3926		
LPA diameter	Smokers	17.44	2.1675	2.173	**0.039**
	Non-smokers	15.588	2.1210		

[Table/Fig-3]: Comparison of MPA, RPA and LPA diameters in the age group <50 years in smokers and non-smokers.

In the 50-60 years age group, which included 17 patients in both smokers and non-smokers group, a significant difference (p<0.05) was found in mean MPA diameter between smokers and non-smokers, while no significant difference (p>0.05) was found in RPA and LPA diameters [Table/Fig-4].

Parameters	Age (50-60 years)	Mean (mm)	SD (mm)	t-value	p-value
MPA diameter	Smokers	30.541	3.0972	5.055	**<0.001**
	Non-smokers	25.165	3.10		
RPA diameter	Smokers	16.171	3.1464	0.935	0.357
	Non-smokers	15.182	3.0136		
LPA diameter	Smokers	16.606	2.7671	0.947	0.351
	Non-smokers	15.829	1.9441		

[Table/Fig-4]: Comparison of MPA, RPA and LPA diameters in the age group 50-60 years in smokers and non-smokers.

In the >60 years age group, which comprised 23 patients in the smokers group and 16 patients in the non-smokers group, a significant difference (p<0.05) was observed in mean MPA, RPA, and LPA diameters between smokers and non-smokers [Table/Fig-5].

Parameters	Age (>60 years)	Mean (mm)	SD (mm)	t-value	p-value
MPA diameter	Smokers	34.035	5.2151	5.869	**<0.001**
	Non-smokers	26.488	2.7456		
RPA diameter	Smokers	19.917	4.51	4.643	**<0.001**
	Non-smokers	14.875	2.1724		
LPA diameter	Smokers	18.23	4.39	2.183	**0.036**
	Non-smokers	15.969	1.9311		

[Table/Fig-5]: Comparison of MPA, RPA and LPA diameters in the age group >60 years in smokers and non-smokers.

Additionally, there was a positive correlation (p<0.001) between age and MPA diameter, as well as age and RPA diameter (p<0.05). However, there was no significant correlation (p>0.05) between age and LPA diameter in smokers [Table/Fig-6].

Lastly, there was no significant correlation (p>0.05) between age and MPA diameter, age and RPA diameter, or age and LPA diameter among non-smokers [Table/Fig-7].

Smokers		MPA diameter (mm)	RPA diameter (mm)	LPA diameter (mm)
Age (years)	Pearson correlation	0.514	0.449	0.202
	p-value	**<0.001**	**0.001**	0.159

[Table/Fig-6]: Correlation of MPA, RPA and LPA diameter with age in smokers.

Smokers		MPA diameter (mm)	RPA diameter (mm)	LPA diameter (mm)
Age (years)	Pearson correlation	0.085	0.083	0.124
	p-value	0.557	0.568	0.393

[Table/Fig-7]: Correlation of MPA, RPA and LPA diameter with age in non-smokers.

DISCUSSION

Early detection of Pulmonary Hypertension (PH) may be achieved by measuring the pulmonary artery diameters in smokers undergoing CECT thorax. While a chest X-ray can visualise pulmonary artery enlargement, CT imaging is a more effective modality for measuring pulmonary artery size [13].

In this study, maximum number of cases in smokers (46%) was seen in the age group of >60 years. Smokers above 60 years of age showed a mean Main Pulmonary Artery (MPA) diameter of 34.03 mm. In an analysis by Steiger D et al., they enrolled 1949 smokers [15]. Patients aged ≥55 years surpassed the MPA ≥34 mm cut-off. Comparable results were found in the present study. Their study revealed that advancing age affected the diameter of the ascending aorta more than the MPA diameter.

The authors in this study found a significant difference (p<0.001) in MPA diameter between smokers and non-smokers. In a study by Lee SH et al., involving 2547 individuals with diverse clinical conditions like smoking history, diabetes, obesity, hypertension, and obstructive lung disease, and another group of 813 healthy individuals, a significant difference was found (p<0.001) in the mean MPA diameter between smokers and non-smokers [16]. They found the mean MPA diameter in smokers was 26.9±3.4 mm and in non-smokers was 26.4±3.4 mm. They also discovered a significant correlation (p<0.001) between age and MPA diameter in the group with diverse clinical conditions. In our analysis, a significant correlation (p<0.001) was found between age and MPA diameter in smokers. The authors also found a significant correlation (p<0.05) between age and Right Pulmonary Artery (RPA) diameter, but no significant correlation (p>0.05) between age and Left Pulmonary Artery (LPA) diameter in smokers. They found that in diverse clinical conditions, the mean MPA diameter in males was 27±3.4 mm and in females was 26±3.4 mm.

In this study, the mean MPA diameters in non-smokers within the age groups <50, 50-60, and >60 years were 25.612 mm, 25.165 mm, and 26.488 mm, respectively. Similar findings were reported in a study conducted by Lee SH et al., [16], where 813 healthy individuals (187 men and 626 women) were divided into age groups <45, 45-54, and ≥55. The mean MPA diameter for males in these age groups was 26 mm, 27 mm, and 26.3 mm, respectively, which closely aligns with our study. For females, the mean MPA diameter in these age groups was 24.4 mm, 25.4 mm, and 27 mm, respectively. They also noted a significant correlation (p<0.001) between age and MPA diameter, mentioning that advancing age affected the diameter of the ascending aorta more than that of the MPA diameter. The present study did not find a significant correlation (p>0.05) between MPA, RPA, and LPA diameters with age in non-smokers.

This study found a significant correlation between MPA (p<0.001) and RPA (p<0.05) diameter with age in smokers. However, no significant correlation (p>0.05) was found between age and LPA diameter in smokers. In a study by Chung KS et al., involving 226 COPD patients with ≥10 pack years of smoking, they observed a significant correlation (p<0.05) between age and body surface area with MPA diameter [17].

In this study, the mean diameters of the MPA in non-smokers were 25.740±2.65 mm, RPA 14.828±2.5256 mm, and LPA diameter 15.792±1.967 mm, respectively. A survey by Bozlar U et al., involving 126 normal patients in the age group of 19-46 years, found the mean diameters of MPA to be 24±2.8 mm, RPA 16.1±1.9 mm, and LPA 18.2±2 mm [18]. They found that the mean LPA diameter was greater than the RPA diameter, similar to the present study. Additionally, the authors did not find a significant correlation (p>0.05) in non-smokers between age and MPA, RPA, and LPA diameters. However, Bozlar U et al., found a significant correlation (p<0.05) between age and RPA and LPA diameters, but no significant correlation (p>0.05) was found between age and MPA diameter. They also found a significant correlation (p<0.05) between MPA diameter, weight, and Body Mass Index (BMI). Furthermore, there was a significant correlation (p<0.05) of BMI with RPA and LPA diameter.

In their study, the mean MPA diameter in males was 24.3±2.5 mm and in females was 23.3±3.6 mm. The mean RPA diameter in males was 16.2±2 mm and in females was 15.6±1.6 mm. The mean LPA diameter in males was 18.4±2.1 mm and in females was 17.4±1.5 mm. Although the mean diameters were larger in males compared to females, there was no significant difference (p>0.05) in MPA and RPA diameter between males and females. Only the LPA diameter showed a significant difference (p<0.05) between males and females. In our study, the range of upper and lower limits of MPA diameter in non-smokers were 32.3 mm and 18.9 mm, RPA diameter 23 mm and 9 mm, and LPA diameter 19.6 mm and 9.6 mm. Almost similar results were seen in their study; the following range of upper and lower limits were observed: MPA diameter 29.5 mm and 18.5 mm, RPA diameter 19.8 mm and 12.4 mm, and LPA diameter 22.1 mm and 14.3 mm.

In this study, the mean MPA diameter in smokers was 31.906 mm±4.5259 mm. In a survey by De-Torres JP et al., involving 188 patients with COPD with ≥10 pack years of smoking [19], they found that the pulmonary artery diameter with pulmonary artery enlargement was 32.9±3.5 mm, and without pulmonary artery enlargement was 23.7±2.8 mm. Terzikhan N et al., performed cardiac CT on 2524 patients [20]. The diameter of the pulmonary artery did not show much variation in current, former, and never smokers. The diameter was 26.0±3.9 mm in current smokers, 26.1±3.6 mm in former smokers, and 25.8±3.7 mm in never smokers. We found similar findings in the case of non-smokers, with a mean MPA diameter of 25.740±2.6562 mm. However, the MPA diameter in smokers was 31.906 mm±4.5259 mm.

Paul TK et al., performed a study on asymptomatic individuals in the Appalachian region [21]. The mean MPA diameter in ever smokers was 26.33±4.22 mm, and in never smokers was 25.91±4.17 mm. They found that smoking history did not differ significantly. In contrast, the authors of present study found a significant difference (p<0.001) in the MPA diameter between smokers and non-smokers.

In this study, the mean MPA diameter in smokers was 31.906 mm±4.5259 mm, and in non-smokers was 25.740±2.6562 mm. Truong QA et al., studied asymptomatic individuals based on the Framingham Heart Study. They found the MPA diameter in smokers was 25.0±2.7 mm, in former smokers 25.1±3.0 mm, and in never smokers 25.2±2.8 mm [22].

Limitation(s)

The study population consisted only of males, as no female smokers were encountered during the study period based on the history taking. The authors in this study did not consider the duration and pack years of smoking. To fully comprehend the relationship between pulmonary artery diameters and the variables of sex, pack years of smoking, and BMI, further study is necessary. Cut-off values for pulmonary hypertension in smokers of different ages were not determined. However, to obtain accurate results, further research with larger sample sizes is required.

CONCLUSION(S)

The diameters of the MPA, RPA, and LPA were larger in smokers compared to non-smokers, and this difference was statistically significant. There was a significant correlation between the mean MPA and RPA diameter according to age group in smokers. However, no significant correlation was observed in the mean LPA diameter according to age group in smokers. Furthermore, no significant correlation was found in the mean MPA, RPA, and LPA diameters according to age group in non-smokers. Therefore, assessing pulmonary artery diameters among smokers using CECT thorax might be helpful in diagnosing pulmonary hypertension at an early stage.

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