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Estimation of thoracic aortic dimensions in smokers and non-smokers on Contrast-Enhanced Computed Tomography

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ABSTRACT

Background: Tobacco use is mainly classified into two forms, smokeless and smoking. In India, smoking is mainly in the form of bidis and cigarettes. Smoking leads to serious health effects like arterial stiffness and aortic aneurysms. *Aim:* The purpose of this study was to determine the relationship between smoking and aortic diameter among smokers and non-smokers. *Methods:* A case-control study was conducted including 34 smokers and 34 non-smokers. Participants who were referred for contrast-enhanced computed tomography (CECT) thorax were included. The diameters of ascending aorta, proximal and distal arch of aorta and descending aorta were measured in the arterial phase using distance measuring tools. *Results:* In smokers, the mean diameter of ascending aorta, proximal and distal arch of the aorta and descending aorta were 30.51 ± 2.96, 25.38 ± 3.20, 22.70 ± 2.33 and 23.28 ± 2.02, respectively. In non-smokers, the mean diameters of ascending aorta, proximal and distal arch of the aorta and descending aorta were 31.32 ± 4.54, 25.42 ± 3.10, 22.77 ± 3.41 and 23.54 ± 3.25 respectively. *Conclusion:* According to the current study, there was no significant difference between smoking and aortic diameter among smokers and non-smokers. The duration of smoking has no effect on ascending aorta, proximal and distal arch of aorta and descending aorta.

Keywords: Ascending aorta, Descending aorta, Contrast-enhanced computed tomography, Multi-planar reformation

1. INTRODUCTION

Worldwide, tobacco consumption is one of the foremost causes of mortality and morbidity (WHO, 2015). It has been recorded that tobacco use can lead to serious health effects (WHO, 2010). In the modern lifestyle, smoking is often joined with coffee drinking. Studies have shown that caffeine and smoking harm blood pressure and cardiovascular risk (Saladini et al., 2016; Crocq, 2003). Also, previous studies have shown that active and passive smoking

leads to increased arterial stiffness (Mahmud and Feely, 2004). Smoking is the leading cause of the progression of abdominal aorta aneurysms (AAA). Prolonged smoking in individuals with an AAA leads to increased expansion rates and the risk of rupture (Sweeting et al., 2012).

The aorta is a complex organ that arises from the aortic ring adjoining the aortic root with the basis of the two vital coronary arteries and terminates at the iliac bifurcation (Erbel and Eggebrecht, 2006). The thoracic aorta is classified into five sections: Aortic root, ascending aorta, proximal aortic arch and distal aortic arch and descending thoracic aorta. The aortic root is part of the aorta originating from the heart base and it contains the valve, annulus and 2 sinuses of Valsalva. The standard size of the aorta is 3.6cm (can vary from 2.4 to 4.7cm).

The regular size of the ascending aorta is 3.5cm (2.2 to 4.7cm). The average diameter of the distal descending aorta is 2.42cm (1.4 to 3.3cm) (Mao et al., 2008; Boiselle, 2003). Computed tomography (CT) imaging is used to evaluate thoracic diseases (Bhalla et al., 2019; Dhok et al., 2022). In this study, we intend to measure the diameters of ascending aorta, descending aorta and proximal and distal arch of the aorta of smokers and non-smokers on contrast-enhanced computed tomography (CECT) thorax.

2. MATERIAL AND METHODS

The study design was a random sampling, case-control study, approved by the Institutional Ethics Committee (REG NO.EC/NEW/INST/2020/834). CECT thorax examination of 68 patients including 34 smokers and 34 non-smokers was performed in Justice K.S. Hegde Charitable Hospital, Department of Radiodiagnosis and Imaging, Mangalore, India from July to December 2022. All patients who were referred for CECT thorax within the age group of 30-80 years were included. Patients with a history of cardiac failure, trauma patients and known cases of vasculitis and a history of previous aortic intervention patients were excluded.

Written consent was taken from all the participants explaining the risk and benefits of the scan. CECT thorax scans were performed on GE Revolution EVO 128 slice with the set protocol. Before performing a scan, the procedure was explained to the patient. Then the patient was asked to change into a hospital gown and an IV cannula was inserted. The patient was positioned supine feet first and the laser beam was centred 2.5cm above the sternal notch. Then appropriate protocol was selected and a scan was performed. First, a scout image was obtained and the plain scan was planned on it. After the plain scan, a contrast scan was planned on the scout image and 60- 80ml contrast media was given at a flow rate of 3ml/sec.

The acquired contrast thorax scan images were reconstructed into the three planes, i.e., sagittal, axial and coronal, via the Multi-planar Reformation (MPR) technique. The measurement of the diameters of ascending aorta, arch of aorta proximal and distal part, and descending aorta were obtained from distance measuring tools in the arterial phase (Figure 1, 2, 3, 4). On the reconstructed axial images, the ascending aorta was measured between T4-T5 levels and descending aorta was also measured on the axial images between T6-T7 levels.

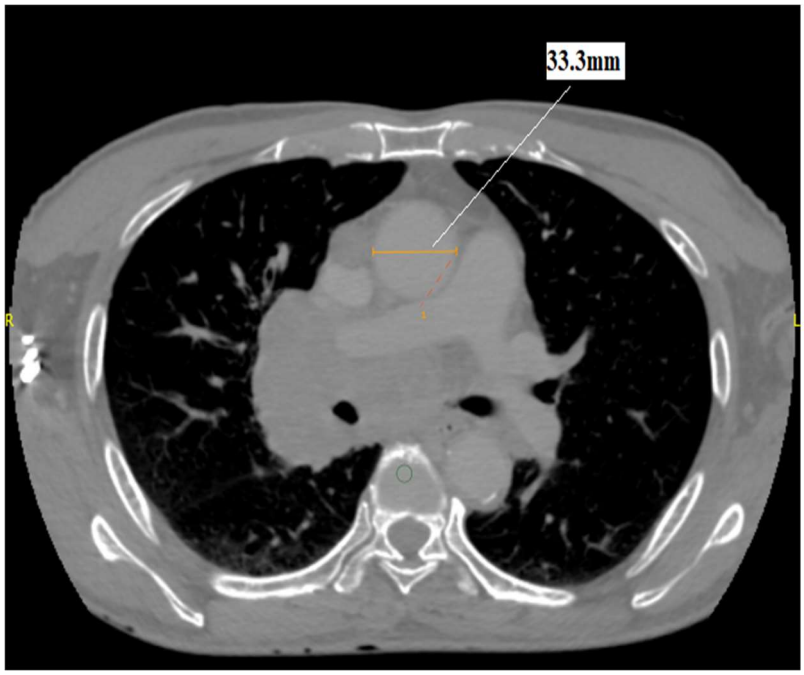

Figure 1 Measurement of Ascending aorta

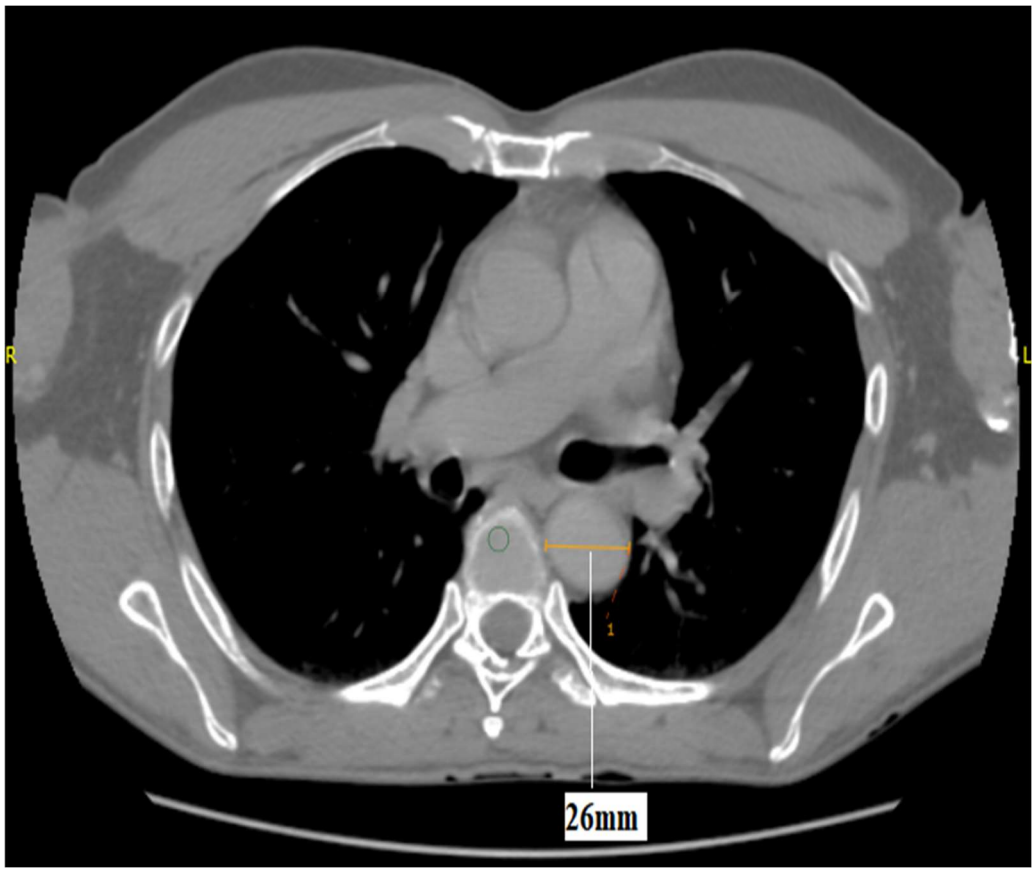

Figure 2 Measurement of Descending aorta

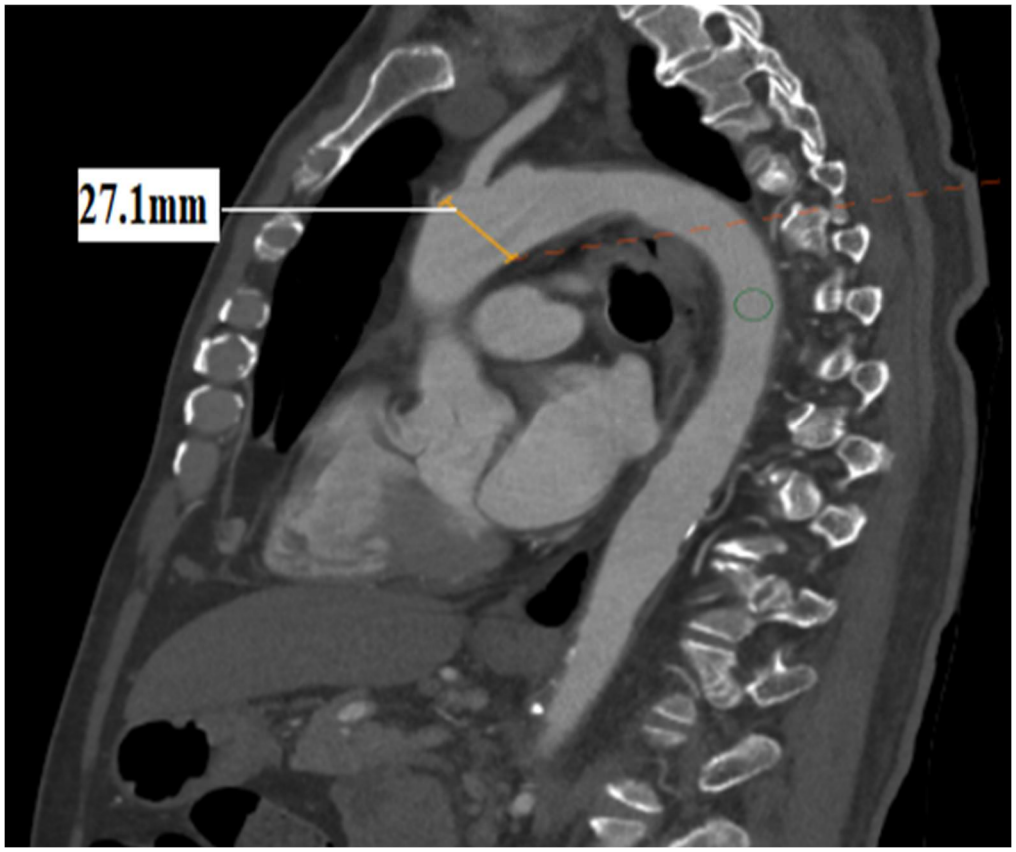

Figure 3 Measurement of Arch of aorta-Proximal

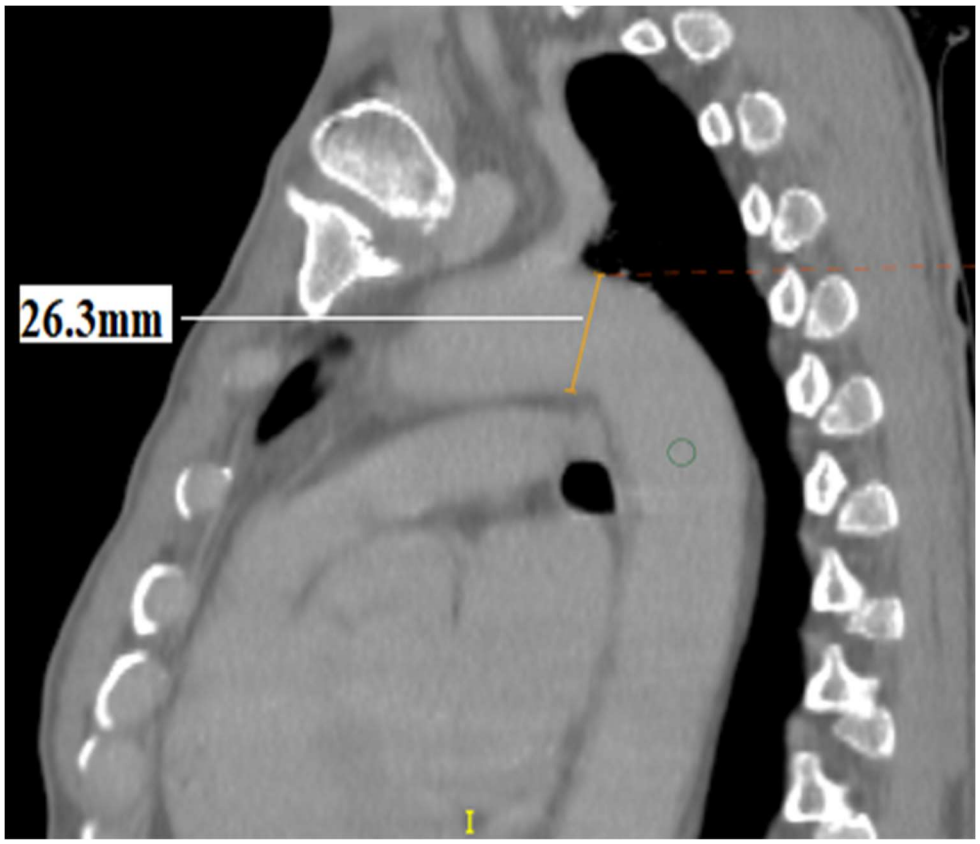

Figure 4 Measurement of Arch of the aorta- Distal

On the reconstructed sagittal images, the proximal arch of the aorta is measured between the brachiocephalic artery and the left common carotid artery. The distal arch of the aorta is measured when the left subclavian artery is visible. The data were analysed with Microsoft Excel -2020 and Statistical analysis was done using Statistical Packages for Social Sciences (SPSS) Version 21.0.

3. RESULTS

A comparison of aortic parameters was obtained between smokers and non-smokers. The mean diameter of ascending aorta (AA) for smokers was 30.51 ± 2.96 and for non-smokers was 31.32 ± 4.54. The mean diameter of the proximal arch of the aorta (AOA-P) was 25.38 ± 3.20 and 25.42 ± 3.10 and the distal arch of the aorta (AOA-D) mean diameter was 22.70 ± 2.33 and 22.77 ± 3.41 for smoker and non-smoker individually. The mean diameter of descending aorta (DA) for smokers were 23.28 ± 2.02 and for non-smokers 23.54 ± 3.25 (Table 1) (Figure 5). The Independent sample "t" test compared AA, AOA-P, AOA-D & DA (mm) between smokers and non-smokers. We found that there was no statistically significant difference ($p > 0.05$) in AA, AOA-P, AOA-D & DA (mm) between smokers and non-smokers.

Table 1 Comparison of Aortic parameters (mm) between smokers and non-smokers

Parameters	Groups	Mean	"t"	p-value
AA	Smoking	30.51 ± 2.96	-0.874	0.385
	Non-smoking	31.32 ± 4.54		
AOA-P	Smoking	25.38 ± 3.20	-0.050	0.960
	Non-smoking	25.42 ± 3.10		
AOA-D	Smoking	22.72 ± 2.33	-0.066	0.947
	Non-smoking	22.77 ± 3.41		
DA (mm)	Smoking	23.28 ± 2.02	-0.389	0.698
	Non-smoking	23.54 ± 3.25		

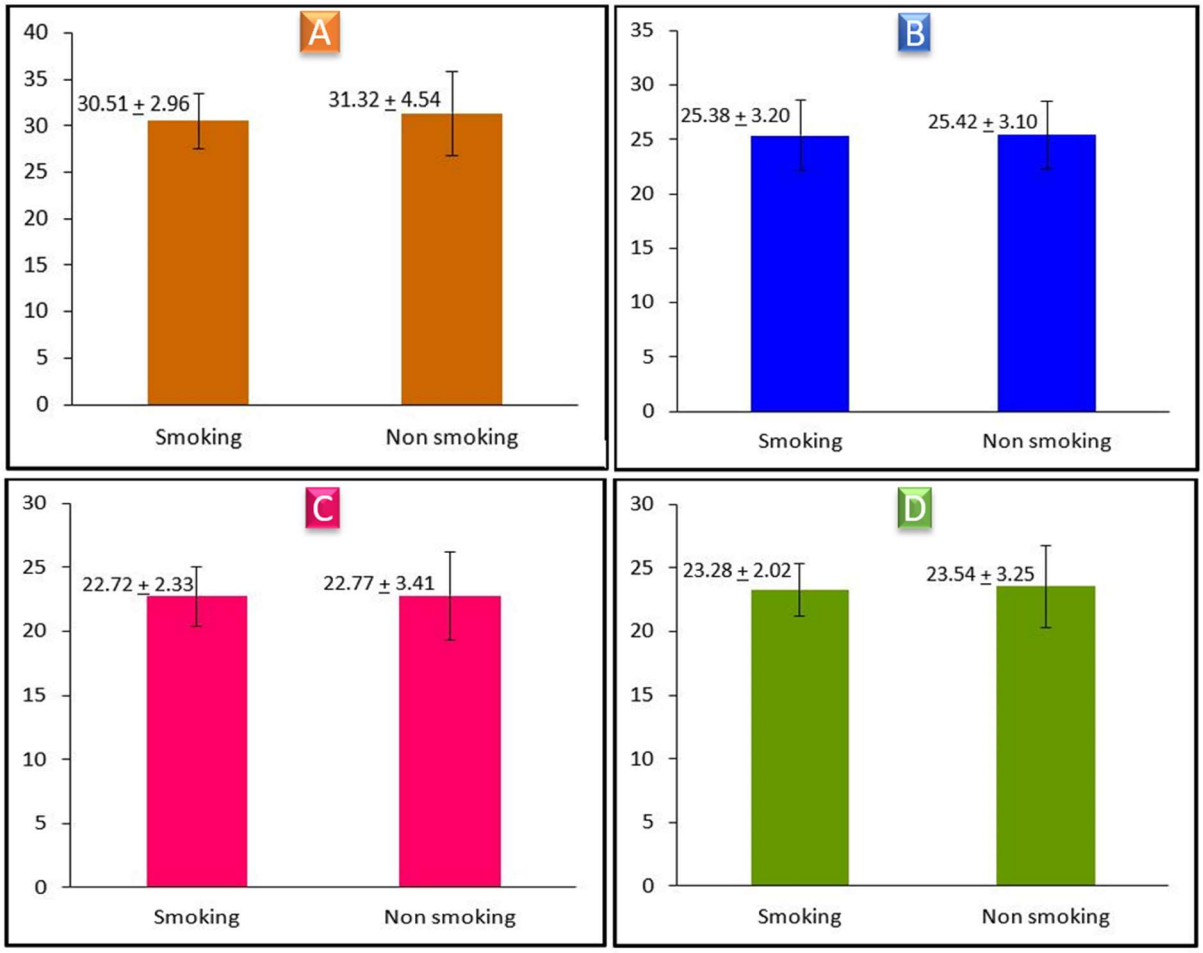

Figure 5 Bar graphs showing the difference in aortic diameters in smokers and non-smokers; (A) ascending aorta; (B) proximal arch of aorta; (C) distal arch of aorta; and (D) descending aorta

Table 2 Comparison of Aortic parameters according to years of smoking

Aortic parameters	Duration of smoking	Mean (mm)	"F"	p-value
AA	5 to 10 Years	29.95 ± 4.30	0.276	0.760
	10 to 20 Years	30.29 ± 2.75		
	> 20 Years	30.86 ± 2.44		
AOA-P	5 to 10 Years	23.80 ± 4.85	1.328	0.280
	10 to 20 Years	26.11± 1.72		
	> 20 Years	25.75 ± 2.73		
AOA-D	5 to 10 Years	21.94 ± 2.59	0.582	0.565
	10 to 20 Years	22.94 ± 2.31		
	> 20 Years	22.98 ± 2.28		
DA (mm)	5 to 10 Years	22.88 ± 3.08	0.678	0.515
	10 to 20 Years	22.83 ± 1.66		
	> 20 Years	23.67 ± 1.60		

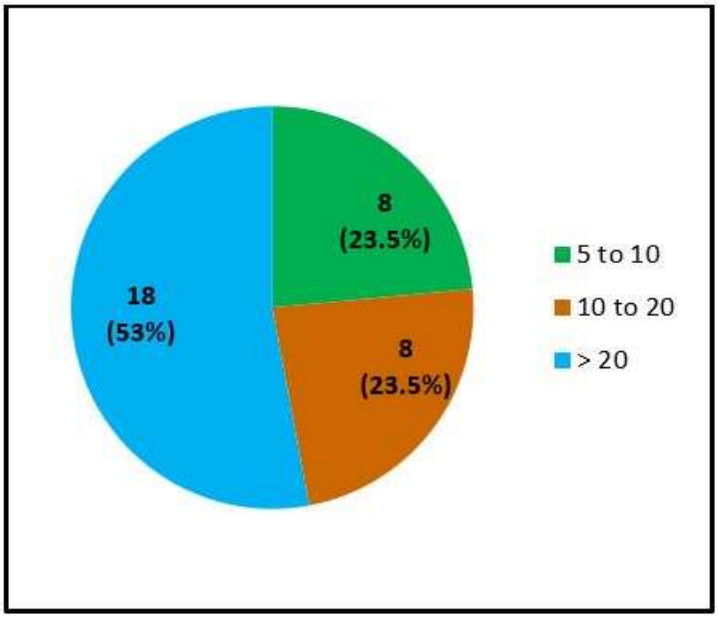

Figure 6 Pie chart showing distribution as per years of smoking

The mean diameter of ascending aorta (AA) from 5 to 10 years is 29.95 ± 4.30, 10 to 20 years is 30.29 ± 2.75 and more than 20 years is 30.86 ± 2.44. The mean diameter of the proximal arch of aorta (AOA-P) from 5 to 10 years is 23.80 ± 4.85, from 10 to 20 years is 26.11 ± 1.72 and more than 20 years is 25.75 ± 2.73. The mean diameter of the distal arch of aorta (AOA-D) from 5 to 10 years is 21.94 ± 2.59, from 10 to 20 years is 22.94 ± 2.31 and more than 20 years is 22.98 ± 2.28. The mean diameter of descending aorta (DA) from 5 to 10 years is 22.88 ± 3.08, 10 to 20 years is 22.83 ± 1.66 and more than 20 years is 23.67± 1.60 (Table 2) (Figure 6). According to years of smoking, we found no statistically significant difference ($p>0.05$) in AA, AOA-P, AOA-D and DA (mm).

4. DISCUSSION

The shape and size of the aorta vary, much among individuals of different ages. The average size of the aorta is 3.6cm (range: 2.4 to 4.7cm). The dimension of the ascending aorta is 3.5cm (range: 2.2 to 4.7cm). The average diameter of the mid-descending thoracic aorta is 2.48cm (range: 1.6 to 3.7cm) (Aronberg et al., 1984). Multi-slice CT permits scans with more rapidity and finer collimation (Hu et al., 2000) (Table 3). We investigated 68 subjects with an age limit of 30-80 years in the present study. Out of 68 subjects, they were classified into 34 smokers and 34 non-smokers. Further, based on the duration of smoking, smokers were divided into three groups: 5-10 years, 10-20 years and more than 20 years.

Table 3 Comparison of ascending aorta by different observers

Author's	Ascending aorta (mm)	
	Smoker	Non-smoker
Wolak et al., (2008)	-	Pulmonary artery bifurcation: 34.0 ± 4.1
Rodriguez-Palomares et al., (2016)	-	Outer edge: 37.4 ± 5.1 Inner edge: 35.6 ± 5.2
Koju and Joshi, (2018)	-	28.8 ± 3.8
Bons et al., (2019)	Pulmonary artery bifurcation: 36.0 ± 3.5	-
Ismail et al., (2021)	Annulus: 24.17±2.42 Sinus: 35.31±3.57	Annulus: 22.58±2.45 Sinus: 33.01±3.88
Present study/2022	T4-T5 vertebrae levels: 30.51 ± 2.96	T4-T5 vertebrae levels: 31.32 ± 4.54

In the present study, we measured the ascending aorta in smokers and non-smokers. The diameter of the same in smokers and control has no significant differences ($p > 0.05$) (Table 3). The ascending aorta was measured at the T4-T5 vertebrae in the current study, whereas other researchers also measured at the same level, but their calculation of ascending aorta was when they immediately found the pulmonary artery bifurcation instead of T4/5 vertebrae (Tucker et al., 2023). In the present study in the non-

smoker's category, we found that the ascending aorta diameter was 31.32 ± 4.54 whereas, in a study conducted in the same category of California population got 34 ± 4.1 (Wolak et al., 2008).

A similar study performed in Spain found that ascending aorta in non-smokers was 37.4 ± 5.1 (Rodriguez-Palomares et al., 2016). The difference in the mean value might be due to sampling size variations in the studies. In the current study, we measured the proximal arch of aorta when the brachiocephalic artery was seen and the distal arch of aorta was measured when the left subclavian artery was visible. We found the mean diameter of the proximal arch of the aorta to be 25.42 ± 3.10 and the distal arch of the aorta was 22.77 ± 3.41 in non-smokers.

A study by Koju and Joshi, (2018) found the proximal arch of the aorta to be 28.7 ± 3.5 and the distal arch of the aorta 24.7 ± 2.8 in normal individuals. They measured proximal and distal arch of aorta diameters at levels: Proximal aorta to innominate artery and distal transverse aortic arch. The mean values were comparatively lesser in the present study. This variation might be due to the measurement of the proximal and distal arch of the aorta at different levels compared to their study.

In the present study in the smoker's category, when we measured ascending aorta, the diameter was 30.51 ± 2.96 in the Indian population whereas a study performed in the Danish lung screening trial group found that the diameter was 36.0 ± 3.5 (Bons et al., 2019) (Table 4). There was a wide difference noted in the Danish lung screening trial group. The difference in these two studies might be due to racial and ethnic factors.

Table 4 Comparison of descending aorta by different observers

Author's	Descending aorta (mm)	
	Smoker	Non-smoker
Wolak et al., (2008)	-	Pulmonary artery bifurcation: 25.6 ± 2.8
Koju and Joshi, (2018)	-	Diaphragm: 22.0 ± 3.1
Bons et al., (2019)	Pulmonary artery bifurcation: 28.2 ± 2.2	-
Ismail et al., (2021)	Diaphragm: 22.47 ± 2.58 Pulmonary bifurcation: 24.09 ± 2.89	Diaphragm: 21.68 ± 2.63 Pulmonary bifurcation: 23.88±2.88
Present study/2022	T6-T7 vertebrae level: 23.28 ± 2.02	T6-T7 vertebrae level: 23.54 ± 3.25

We measured the descending aorta in smokers and non-smokers in this study at the vertebrae level of T6-T7. We found that the mean diameter of descending aorta in smokers and non-smokers has no significant difference ($p > 0.05$) (Table 4). The mean diameter of descending aorta in non-smokers was 23.54 ± 3.25 in the current population whereas, a study performed in California got a mean diameter of 25.6 ± 2.8. The measurement was obtained from descending aorta when they saw pulmonary bifurcation in the axial image (Wolak et al., 2008).

Similarly, another study performed in the Nepal population measured the dimension of descending aorta at the diaphragmatic level and the mean diameter was 22.0 ± 3.1 (Koju and Joshi, 2018). There was a slight variation in mean values. This might be due to differences in the study population concerning geographical factors. In the current study in the smoker's category, we measured descending aorta between the T6-T7 vertebrae levels and we found the diameter was 23.28 ± 2.02 in the Indian population.

A study by Bons et al., (2019) conducted a study on a Danish lung screening trial group, measured the descending aorta when they saw pulmonary artery bifurcation and found the mean diameter, 28.2±2.2 in smokers. While comparing with the present study, a wide variation was seen in descending aortic diameters. This difference might be due to measurement level, as we measured at T6-T7 vertebrae levels.

Comparison of aortic parameters based on the duration of smoking by different observers

In the current study, the mean diameter of ascending aorta in smokers was 29.95 ± 4.30 and that of descending aorta was 22.88 ± 3.08. A study performed on current Brazilian smokers, measured ascending aorta at the level of origin, 2 cm closely proximal to the brachiocephalic trunk and descending aorta at 5 cm to the root of the left subclavian artery. They found the mean diameter of ascending aorta to be 33.6 mm and descending aorta to be 28.4 mm (Lembranca et al., 2021). The mean value in the present study was comparatively less. The difference might be due to the pack-smoking years considered by them, as they measured aortic dimensions in current smokers and the present study measured the same between three age groups of 5-10 years, 10-20 years and more than 20 years.

Another study by Mc-Comb et al., (2016) conducted in Florida, found that the mean diameter of ascending aorta was 33.7 ± 4.0, and that of descending aorta was 25.6 ± 2.9 in 30 to <40 pack-years of smoking. The current study found the mean diameter of

ascending aorta as 30.86 ± 2.44 and that of descending aorta as 23.67 ± 1.60 in patients with more than 20 years of smoking. A variation was noted in Indian and Florida populations suggesting that the Florida population's ascending aorta and descending aorta dimensions are higher than the Indian population. This variation might be due to the different exposure to smoking.

When we considered just the duration of smoking, they considered pack years of smoking. Thus, aortic dimensions can be measured using a CT scan in different age groups. The variation of aortic measurements in the present study compared to other studies might be due to sampling size and a combination of other factors like patient size, years of smoking and genetic and environmental factors. The limitation of the present study is that we didn't include female patients.

5. CONCLUSION

The diameters of the ascending aorta, proximal and distal arch of the aorta and descending aorta in smokers and non-smokers showed no significant difference. Smokers showed no significant difference based on the duration of smoking. Previous studies showed that smoking could cause thoracic aorta diseases irrespective of aortic dimensions.

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Author Contributions

We certify, as authors, that we have participated sufficiently in the study concepts, conception and design of this study. The guarantor of the integrity of the entire study was done by Jaseemudheen. The literature research and manuscript writing were done by Swati Kumari. Manuscript editing and critical revision were done by Jaseemudheen. Both authors read and approved the final manuscript. All persons who have made substantial contributions to the work reported in the manuscript.

Ethical approval

The study was approved by the Institutional Ethics Committee (REG NO.EC/NEW/INST/2020/834).

Informed consent

Written & Oral informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this manuscript.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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