ADDIS ABABA UNIVERSITY

COLLEGE OF MEDICINE AND HEALTH SCIENCES

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF RADIOLOGY

ASSESSMENT OF THORACIC AORTA DIAMETERS USING CONTRAST ENHANCED CHEST COMPUTED TOMOGRAPHY IN ETHIOPIAN ADULTS AT TIKUR ANBESSA SPECIALIZED HOSPITAL: AN INSTITUTION-BASED CROSS-SECTIONAL STUDY.

DR. HAWI FARRIS (MD, GENERAL RADIOLOGIST, CARDIOTHORACIC IMAGING FELLOW)

A RESEARCH THESIS SUBMITTED TO THE DEPARTMENT OF RADIOLOGY, COLLEGE OF HEALTH SCIENCES, ADDIS ABABA UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE POSTGRADUATE SUB-SPECIALTY STUDY IN CARDIOTHORACIC IMAGING.

February 2025

ADDIS ABABA, ETHIOPIA

ADDIS ABABA UNIVERSITY

COLLEGE OF MEDICINE AND HEALTH SCIENCES

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF RADIOLOGY

Assessment of Thoracic Aorta Diameters using Contrast-enhanced Chest Computed Tomography in Ethiopian Adults at Tikur Anbessa Specialized Hospital: An Institution-Based Cross-Sectional Study.

Primary investigator: Dr. Hawi Farris (MD, Assistant professor of radiology, Cardiothoracic imaging fellow)

Advisors:

Dr. Azmera Gissila (MD, Assistant professor of radiology, Cardiothoracic imaging subspecialist)

Dr. Amir Alwan (MD, Assistant professor of radiology, Cardiothoracic imaging subspecialist)

Dr .Yimaj Abdulwahab (MD, Assistant professor of radiology, Cardiothoracic imaging subspecialist)

February 2025

Addis Ababa, Ethiopia

Acknowledgment

I would like to express my appreciation to the Department of Radiology, CHS, and Addis Ababa University for allowing me to undertake this research.

I sincerely thank my advisors for their valuable suggestions and comments during the preparation of this thesis.

Finally, I would like to extend my gratitude to the CT technologists and nurses in the Radiology Department of Addis Ababa University for their cooperation during the data collection process.

Table of contents

List of Tables

List of Figures

List of acronyms and abbreviations

AA	Aortic Arch
AR	Aortic Root
ATA	Ascending Thoracic Aorta
BSA	Body Surface Area
CVD	CardioVascular Diseases
CT	Computed Tomography
ED	End Diastole
ES	End Systole
DTA	Descending Thoracic Aorta
MRI	Magnetic resonance imaging
SD	Standard Deviation
SOV	Sinus Of Valsalva
STJ	Sinotubular Junction
SPSS	Statistical Package of Social Sciences
TASH	Tikur Anbessa Specialized Hospital
TA	Thoracic Aorta

Abstract

Background: The diameter of the thoracic aorta (TA) is a crucial factor in assessing cardiovascular health, as deviations from normal ranges can indicate underlying pathological conditions, such as aortic dilatation and aneurysm. Although substantial research has been conducted worldwide to determine normative data for TA diameters, there is a notable lack of such data for Ethiopian populations. The accuracy, speed, reproducibility, simplicity, and 3D capability of Computed Tomography (CT) have made it the gold standard for evaluating the TA.

Objective: To assess the diameter of the TA at multiple anatomical levels and identify factors correlated with its diameter in adult Ethiopians who visited the Radiology Department at Tikur Anbessa Specialized Hospital between September 1 and November 30, 2024.

Methodology: An institution-based prospective cross-sectional study was conducted using a consecutive sampling method. Data were collected from consecutive eligible adults who came for contrast-enhanced CT scans during the study period, using interviewer-administered structured questionnaires. The data were cleaned and analyzed using SPSS version 27. Descriptive statistics, including frequency, percentages, means, and ratios, as well as the independent Student's t-test, Mann-Whitney U test, and Pearson correlation, were used for statistical analysis. The p-value threshold was set at 0.05.

Results: A total of 386 study participants were included, of whom 244 (63.2%) were females and 142 (36.8%) were males. The mean age was 46.04 ± 15.39 years, with a range of 18 to 86 years. The thoracic aorta showed smooth tapering from the ascending to the descending aorta. The diameters (mean ± SD) at the level of the sinus of Valsalva, STJ, mid-ATA, distal ATA, arch, proximal DTA, mid-DTA, and distal DTA were 35.29 ± 2.60 mm, 27.10 ± 2.71 mm, 33.72 ± 3.35 mm, 32.35 ± 3.29 mm, 29.42 ± 2.82 mm, 26.66 ± 2.89 mm, 23.42 ± 2.49 mm, and 21.80 ± 2.40 mm, respectively. The thoracic aorta diameter at all levels had a statistically significant correlation with age, weight, BSA, and hypertension ($p<0.05$).

Conclusion: This study evaluated the mean diameter of the thoracic aorta at various levels in Ethiopian adults at TASH, providing a normal reference range. It found a statistically significant association of the TA diameter at all levels with age, weight, BSA, and hypertension.

Keywords: Thoracic aorta diameter, association of TA diameter with anthropometric variables, and Computed Tomography.

1. Introduction

1.1 Background

The aorta is pivotal in cardiovascular physiology, serving as the main conduit for oxygenated blood from the heart to the remaining parts of the body. The thoracic aorta (TA) is further divided into four segments: Aortic Root (AR), Ascending Thoracic Aorta (ATA), Aortic Arch (AA), and Descending Thoracic Aorta (DTA). The AR arises from the left ventricle and includes the aortic valve and the sinuses of Valsalva. The sinotubular junction (STJ) delineates this segment from the ATA, The ATA curves to the left posterior hemithorax, forming the AA at the manubrium. The AA is defined from the origin of the brachiocephalic trunk to the ligamentum arteriosum. The DTA runs from the ligamentum arteriosum to the aortic hiatus in the diaphragm, which is roughly at the level of T10 [1,2].

The diameter of the TA is a crucial factor in assessing cardiovascular health, as deviations from normal ranges can indicate underlying pathological conditions, such as aortic dilatation, aneurysms, dissection, connective tissue disorders, and vasculitis. Echocardiography (both Transthoracic and Transesophageal), Computed Tomography (CT) Scan, and Magnetic Resonance Imaging (MRI) are frequently utilized non-invasive imaging techniques for evaluating the TA. The detailed anatomy of different parts of the TA can be effectively displayed on axial and thin-section reconstructed images in various planes. Moreover, the use of 3D and volume rendering applications on advanced CT workstations has made Multidetector CT a widely favored modality for the comprehensive evaluation of TA and its branches [3–7].

Knowing the specific population TA size on CT scans offers substantial benefits for the early diagnosis of aortic diseases in asymptomatic patients, enabling timely intervention and personalized treatment plans. It also assists interventional radiologists and vascular surgeons in selecting the appropriate size for thoracic devices such as angiographic catheters and endovascular aortic stent [3,8–10].

1.2 Statement of the Problems

Cardiovascular diseases (CVD) pose a significant public health challenge due to their high mortality and morbidity rates. The number of prevalent CVD cases nearly doubled, increasing from 271 million in 1990 to 523 million in 2019, while CVD-related deaths steadily rose from 12.1 million in 1990 to 18.6 million in 2019. Additionally, deaths attributed to aortic aneurysms amounted to 172,000 [11]. In Africa, cardiovascular diseases account for 38.3% of non-communicable disease deaths [12]. However, there is a lack of literature on the exact prevalence of aortic aneurysms in Africa, particularly in Ethiopia.

A thoracic aortic (TA) aneurysm is associated with high mortality. Since most patients with TA aneurysms are asymptomatic unless complications arise, early diagnosis primarily depends on imaging to measure the size of the aorta and compare it with established normal values for the specific imaging modality used [13]. Understanding the factors that influence the diameter of the thoracic aorta is also crucial [14].

Although substantial research has been conducted globally, and a few studies in Africa[14,15] have examined normative data for TA diameters, there is a notable lack of such data for the Ethiopian adult population. As a result, clinicians are forced to rely on reference values established by Western populations, which may not be entirely applicable to Ethiopian adults due to genetic, environmental, and lifestyle differences that may affect vascular dimensions.

To the best of the writer's knowledge, no studies have been conducted on TA diameter in Ethiopia's adult population. This gap in knowledge presents a challenge for healthcare professionals in the early diagnosis and effective management of aortic diseases.

Currently, vascular surgery services in Ethiopia, including endovascular procedures, are expanding rapidly. However, due to the lack of studies evaluating TA diameters in Ethiopian adults, clinicians are relying on Western data to identify and purchase appropriately sized angiographic catheters and endovascular aortic stents.

1.3 Significance of the study

Computed Tomography (CT) is widely used in the assessment of TA due to its high sensitivity, specificity, and relative availability. Understanding the normal range of TA sizes in Ethiopian adults is crucial for the early identification of patients with aortic dilation and aneurysms. Early detection facilitates timely intervention, potentially preventing life-threatening events. It also enables the customization of treatment plans and monitoring protocols for individuals, particularly for individuals with conditions like hypertension and Diabetes Mellitus (DM), which can affect TA diameters.

In addition, healthcare providers can develop more effective screening programs targeting individuals with abnormal TA diameters. The study will also provide valuable data for interventional radiologists and vascular surgeons in determining the most commonly required thoracic device sizes, such as angiographic catheters and endovascular aortic stents.

This study aims to assess the mean diameter of the TA at different segments using post-contrast chest CT scans at Tikur Anbessa Specialized Hospital (TASH). It will also explore the associations between TA size and various demographic, anthropometric, and clinical parameters, including sex, age, weight, height, Body Mass Index (BMI), Body Surface Area (BSA), hypertension, DM, and smoking.

As one of the largest and most prominent hospitals in Ethiopia, TASH provides access to a large and diverse study population, ensuring a comprehensive and representative data set.

In summary, understanding the distribution of TA size within a population is crucial for enhancing the detection, prevention, and treatment of aortic diseases. It also contributes to improving clinical practices, guiding research, and informing healthcare policies.

2. Literature review

Thoracic aorta histologically composed of tunica intima, media and adventitia which are adapted to withstand the high pressures generated by the heart during systole and the elastic recoil that propels blood forward during diastole. The proportion of elastic fibers in the tunica media is particularly high in the artery compared to the abdominal aorta to accommodate these demands. As individuals age, the structure of the wall of the aorta undergoes changes characterized by elastin fragmentation, fibrosis, and medial necrosis [16]. Additionally, different diseases can change the structure and function of the TA, potentially leading to focal, segmental, or diffuse dilatation or stenosis of the vessel [17].

Different imaging methods have been utilized to evaluate and monitor such structural abnormalities. Decisions regarding diagnosis and treatment often depend substantially on comparing measured aortic diameters to normal values. Especially for the definition and classification of structural abnormalities, such as ectasia, aneurysm, and stenosis. The knowledge of population-specific normal TA diameters at different levels in healthy adults is essential for a specific imaging modality [3,4,18–20].

In 2002, Alfred Hager and his colleagues conducted a prospective study in Germany to assess the normal diameter of the TA in adults using contrast-enhanced CT. They examined 70 adults who had thoracic CT scans for reasons unrelated to heart conditions and measured TA diameter at seven levels. The mean ± SD of aortic diameters were as follows: 2.98 ± 0.46 cm at the aortic valve sinus, 3.09 ± 0.41 cm at the ATA, 2.94 ± 0.42 cm just before the innominate artery, 2.77 ± 0.37 cm at the proximal transverse arch, 2.61 ± 0.41 cm at the distal transverse arch, 2.47 ± 0.40 cm at the isthmus, and 2.43 ± 0.35 cm at the diaphragm. They also found an association between TA diameter, sex, and age. Men had significantly larger diameters than women at the ATA, the distal transverse arch, and the diaphragmatic level of DTA. All TA diameters at intra-thoracic levels were significantly increased with age. However, there was no influence of weight, height, or body surface area on TA diameter [18].

A retrospective study was carried out by Juntima Euathrongchit and colleagues to determine the normal size of the TA in Thai adults. The research involved 129 patients who underwent thorax

MDCT scans at Maharaj Nakorn Chiang Mai Hospital between 2004 and 2005. Patients with certain medical conditions, such as renal disease, hypertension, diabetes, congenital heart disease, valvular heart disease, or connective tissue disorders, were not included in the study. They assessed the average diameter of the TA at six specific points using the following levels: level A, 1 cm caudal to the top of the aortic arch; level B, 1 cm cranial to the aortic root; level C, at the diaphragmatic level; and an additional mid-arch level, located between the left common carotid and left subclavian artery. The measurements were taken on correlated axial planes, except for the mid-arch level, which was measured on the mid-oblique coronal view. The study revealed smooth tapering from the aortic root to the ATA and DTA. The mean diameters at various points were: 29.5mm at the distal ATA, 2.59 cm at the mid-arch, 2.33 cm at the proximal DTA, 2.14 cm at the distal DTA, and 2.03 cm at the diaphragm. The researchers also observed that the male aorta mean diameter was significantly larger than that of the female ($p < 0.05$) and that diameters increased significantly with age at all measured levels of the aorta [21].

Arik Wolak and his team conducted a study involving 4,387 individuals aged 26 to 92 years without known coronary heart disease. They underwent non-contrast-gated CT scans for coronary artery calcium at Cedars-Sinai Medical Center in Los Angeles, USA, between July 2004 and March 2007. The goal was to establish normal limits for the diameters of the ATA and DTA across different age groups, genders, and body surface areas (BSA) through precise measurements at the pulmonary artery bifurcation level. Initially, the researchers used multiple linear regression analysis to identify independent risk factors associated with ATA and DTA diameters. Subsequently, individuals exhibiting these factors were left out of the final analysis groups. As a result, the final analysis included only patients whose aortic sizes were not affected by these factors, effectively "normalizing" the data. Hypertension and diabetes mellitus were identified as significant factors influencing ATA diameter, while hypertension and smoking were found to affect DTA diameter. This led to the exclusion of 1,225 subjects from the ATA diameter analysis and 2,286 subjects from the DTA diameter analysis. In the final analysis group, the average aortic diameters for both genders combined were 33 ± 4 mm for the ascending aorta (ATA) and 24 ± 3 mm for the descending aorta (DTA). For females, the average ATA and DTA diameters were 31.4 ± 3.2 mm and 22.6 ± 2.2 mm, with upper normal limits of 37.4 mm and 27.0 mm. For males, the average ATA and DTA diameters were 33.5 ± 3.6 mm and 25.1 ± 2.5 mm, with upper normal limits of 40.7 mm and 30.1 mm. The research found that aortic dimensions are directly affected by both age and body surface area (BSA). However, male gender significantly predicted aortic size only in interaction with age. Specifically, older men tend to have a larger aorta on average compared to women of the same age, although the difference between younger men and women is less pronounced. Formulas were developed to estimate aortic diameter: 14.10 + 0.13 x age (years) + 1.09 (if male) + 0.04 x age (if male) + 5.80 x BSA for the ATA, and 7.73 + 0.11 x age (years) + 0.41 (if male) + 0.02 x age (if male) + 4.91 x BSA for the DTA [22].

Fay Y. Lin and a colleague researched to establish normal values for TA sizes using ECG-gated MDCT. The study involved 103 adults (43% women, average age 51 ± 14 years) who met the criteria of being normotensive, non-obese individuals aged 18 years or older. Participants were free from aortic or cardiac structural issues and arrhythmia and underwent MDCT angiography at either New York Presbyterian Hospital or Tennessee Heart and Vascular Institute between August 2005 and April 2007. Measurements for the TA diameter were conducted using a 3D workstation program. The measurements were taken in double-oblique short axes (D-SAX) at both end-diastole (ED) and end-systole (ES) phases. Specifically, at the sinus of Valsalva level, measurements were made from each coronary sinus to its opposite trigone. At the level where the main pulmonary artery bifurcates, anteroposterior (AP) and lateral diameters were measured for both the ED and ES phases of the ATA and DTA. The research findings indicated that on average, ES TA measurements were higher than ED measurements by 1.9 ± 1.2 mm for the ATA and 1.3 ± 1.8 mm for the DTA, respectively ($P < 0.001$ for both). Men had a larger D-SAX aortic root diameter (3.2 ± 0.6 cm vs. 2.9 ± 0.5 cm), and age and BSA were significant determinants of aortic root diameter in multivariate analysis. Significant differences were seen in aortic root diameter/BSA by age group but not in aortic root diameter by itself (P < 0.001 and P = 0.75, respectively), based on a one-way analysis of variance. Predicted aortic root diameters could be calculated by the equation: aortic root (cm) = 1.02 + (0.99 × BSA) + (0.004 × age) ± 0.50 (R = 0.67, P < 0.001). The 95% confidence intervals for the ED diameters were 2.1-3.5 cm for the ATA and 1.7-2.6 cm for the DTA. In univariate analysis, the ATA diameter varied with age, weight, BSA, BMI, and to a lesser degree, blood pressure. However, in multivariate analysis, only age and BSA were found to be significant. The predicted ATA diameter can be calculated using the equation: Ascending aorta (cm) = 0.59 + (0.72 × BSA) + (0.02 × age) ± 0.62 (R = 0.63, P < 0.001). Similarly, in univariate analysis, the DTA diameter varied with age, sex, BSA, height, weight, BMI, blood pressure, and Stroke volume. In multivariate analysis, age, BSA, and to a lesser degree, stroke volume, were significantly associated with ED DTA diameter. The predicted DTA diameter can be calculated using the following equation: Descending thoracic aorta (cm) = 0.59 + (0.44 × BSA) + (0.01 × age) + (0.02 × SV) ± 0.38 ($R = 0.67$, $P < 0.001$) [23].

A prospective study led by Sang Hwan Lee and coworkers was conducted in 2013 aimed at determining normal reference values for aortic diameters in asymptomatic Korean adults. They included 300 participants scheduled for contrast-enhanced CT scans at Seoul National University Hospital for non-vascular medical reasons. The diameters of the aorta were measured at nine specific anatomical levels: 1) ATA at the middle level of the right main pulmonary artery, 2) transverse aortic arch, 3) proximal DTA at the middle level of the left main pulmonary artery, 4) mid-DTA at mitral valve level, 5) distal DTA at the top of the diaphragmatic level, 6) thoracoabdominal junction, 7) celiac axis, 8) suprarenal aorta just above the renal arteries, and 9) aortic bifurcation. The measurements were recorded at a right angle to the aorta's axis, from the outer edge of one wall to the outer edge of the opposite wall. Aortic diameters (mean ± SD) at different levels were 2.99 ± 0.57 cm at the ATA, 2.54 ± 0.35 cm at the transverse aortic arch, 2.36 ± 0.35 cm at the proximal DTA, 2.23 ± 0.37 cm at the mid-DTA, 2.17 ± 0.38 cm at the distal DTA, and 2.16 ± 0.37 cm at the thoracoabdominal junction. Men had statistically significantly larger diameters compared to women ($p < 0.05$), and all diameters increased with age and hypertension, showing statistical significance ($p < 0.01$). Moreover, all aortic diameters increased with height ($p < 0.05$), except at the level of the aortic arch ($p = 0.056$), and increased with weight ($p < 0.05$) [24].

Hyoung Woo Chang and his colleagues carried out a retrospective study to assess the influence of patient age and anthropometric variables on the size and growth rate of the TA in the general population. The study comprised 2,353 adult (≥ 18 years) Koreans who underwent at least two contrast-enhanced CT scans with at least a 6-year interval from May 2003 to September 2014 at Seoul National University Bundang Hospital, South Korea. The inner diameter of the TA was measured at five specific levels on both the initial and final CT scans. The size of the sinus of Valsalva was measured at its largest dimension visible in axial imaging. The diameter of the aortic root was measured as its shortest dimension at the level of the pulmonary artery bifurcation. The short diameter of the aortic arch was measured on the axial slice, which showed the vessel's maximum extent. The proximal part of the DTA was measured at the same level as the main pulmonary artery, while the distal DTA was measured at the level of the cardiac apex. The mean diameters of the TA were 34.9 ± 4.7 mm at the sinus of Valsalva, 34.1 ± 4.6 mm at the ATA, 28.0 ± 3.8 mm at the aortic arch, 24.8 ± 3.4 mm at the proximal DTA, and 23.8 ± 3.3 mm at the distal DTA. The TA diameter was found to be larger in men compared to women, and this difference was statistically significant only at the level of the ATA ($P = 0.002$). However, when adjusting for BSA by indexing the diameter (dividing the diameter by BSA), women had significantly larger indexed diameters at all five levels ($P < 0.001$). At all five levels, the TA diameter was greater in older participants. All TA segments in subjects in their 70s were 5-10 mm larger than those in patients in their 30s, regardless of gender. Age and BSA were independent predictors and were positively correlated with TA diameter at all five levels, as determined by multivariable linear regression adjusted for sex (R^2 values ranged from 0.212 to 0.393). The growth rate of the interval TA diameter was highest among subjects in their 40s, and this growth rate showed a negative correlation with the initial indexed diameter ($P < 0.001$) across all TA levels. In 40–50% of the subjects, TA size remained stable during the interval [25].

Ahmed Shehata conducted an observational study in Cairo, Egypt, from November 2017 to November 2018, using contrast-enhanced ECG-gated MDCT to establish normal aortic diameter values in the Egyptian population and to identify independent cardiovascular risk factors associated with these measurements in 516 Egyptian adults (aged 20 years and older) undergoing CT coronary angiography. The TA diameter was assessed at several key points during the systolic (40%) and diastolic (75%) phases of the cardiac cycles, and the average of these measurements was computed. Measurements for the aortic annulus, aortic sinus, and sinotubular junction were taken from hinge to hinge distance in the coronal view (from outer upper to inner lower side). Axial measurements (long and short diameters) were taken for the ATA and DTA at the levels of the pulmonary bifurcation and diaphragm. The study found that mean age was 53.5±10.9 and males comprised 61.4% of the study population. The mean weight and height were 88.3±15.5 kg and 169.4±9.7 cm respectively, the mean BMI was 30.9±5.5 cm2/kg, and the mean BSA was 1.984±0.193 m2. Aortic root diameters measured at the annulus, sinus and STJ were 23.09±2.55 mm, 33.75±3.93 mm, and 26.13±3.05 mm, respectively. The BSA-indexed diameters were 11.70±1.39, 17.10±2.10 and 13.25±1.65, respectively. The diameter of the tubular part of ATA was 30.97±4.16 mm, and the BSA-indexed diameter was 15.71±2.28. At the level of the pulmonary bifurcation, the DTA diameters were 24.56±2.95 mm and 23.79±2.96 mm at the systolic and diastolic phases, respectively. Indexed to BSA, these were 12.44±1.52 and 12.05±1.52, respectively. At the diaphragmatic level, the mean diameters were 22.39±2.72 mm at the systolic phase and 21.49±2.79 mm at diastolic phases with BSA-indexed values of 11.34±1.43 and 10.98±1.48, respectively. Multiple linear regression analyses were performed to identify independent predictors of TA diameters at various levels. Gender (male), BSA, and BMI were found to be statistically significant independent predictors of aortic annular diameter ($P < 0.001$, $R=0.53$, adjusted R squared=0.28). For sinus diameter, gender (male), BSA, and age emerged as statistically significant predictors ($P=0.001$, $R=0.56$, adjusted R squared=0.32), while for STJ diameter, gender (male), BSA, and age were significant predictors ($P < 0.001$, $R=0.45$, adjusted R squared=0.20, $P < 0.001$). ATA tubular diameter was predicted by age, BMI, and hypertension ($P < 0.001$, $R=0.38$, adjusted R squared=0.14). Significant predictors of mean DTA diameter at the pulmonary artery level included age, gender, and weight ($P < 0.001$, $R=0.56$, adjusted R squared=0.31), and at the diaphragmatic level included age, BSA, and gender ($P < 0.001$, $R=0.59$, adjusted R squared=0.35) [14].

Sona Pokhrel and Rupesh Sharma conducted another prospective cross-sectional study on 105 adult patients without evident cardiovascular disease who presented at the Department of Radiodiagnosis in Lumbini Medical College, Palpa, Nepal, from February 5th, 2022, to February 4th, 2023. The study aimed to determine the size of the TA, excluding patients with overt aortic atherosclerosis, pulmonary embolism, aortic aneurysm, dissection, stenosis, and aortitis. They used non-gated post-contrast chest CT and measured the internal diameter of the TA at various levels: the aortic valve sinus, ATA, proximal to the innominate artery, transverse aortic arch, distal transverse aortic arch, aortic isthmus, and DTA at the level of the diaphragm perpendicular to the axis of the aorta. Of the total, 54 (51.4%) patients were female and 51 (48.6%) were male, with a mean age of 58 ± 13.93 years old. The mean height, weight, and BMI of the patients were 155.41 cm ± 12.26, 55.10 kg ± 11.09, and 22.60 ± 3.54, respectively. The study found smooth tapering of aortic diameter from the ATA onwards, with the maximum diameter being at the ATA, with a mean of 2.85 cm. This is followed by aortic valve sinus 2.80 cm, 2.68 cm at the proximal to innominate artery, 2.57 cm at the proximal transverse arch, 2.41 cm at the distal transverse arch, 2.24 cm at the isthmus, and 2.03 cm at the DTA at the level of the diaphragm.

The research identified a significant correlation between the mean ATA diameter and the age of the patients ($r = 0.475$, $p < 0.05$). However, the study did not find a significant correlation between aortic diameter and weight, height, or BMI [26].

The 2022 American Heart Association/American College of Cardiology guidelines recommend using eight standard anatomic landmarks for TA measurement in both CT and MRI for the diagnosis and treatment of aortic disease. These landmarks include: at the sinus of Valsalva, sinotubular junction, mid-ATA (midpoint between sinotubular junction and distal ATA), distal ATA (aorta just proximal to the origin of the brachiocephalic trunk), mid-aortic arch (just distal to the left common carotid artery), proximal DTA (2 cm distal to the left subclavian artery), mid-DTA, and DTA at the diaphragm (2 cm above celiac axis origin) (Figure 1). To accurately determine the diameter, measurements should be taken in a plane perpendicular to the direction of blood flow [3,27]. There is no universally accepted standard for whether measurements should be taken from inner edge to inner edge or outer edge to outer edge. It's recommended to maintain consistency within an institution by using the same approach when comparing follow-up images. John A. and his colleagues recommend using the measurement from outer edge to outer edge (wall to wall) because the values obtained this way can be applied to both CT scans with and without contrast. For Sinus Valsalva measurements, the Sinus-to-Commissure or Sinus-to-Sinus methods can be used (Figure 2). Research has shown that diameters measured using the sinus-to-sinus method are generally 2 mm larger on average than those measured by the sinus-to-Commissure method. However, using the sinus-to-sinus method offers several advantages, including easier detection of cusp margins in transverse planes, closer agreement with echocardiographic measurements, and greater feasibility in bicuspid valves [4,28].

Figure 1: Schematic showing standard anatomic landmarks for TA measurement us in both CT and MRI [3].

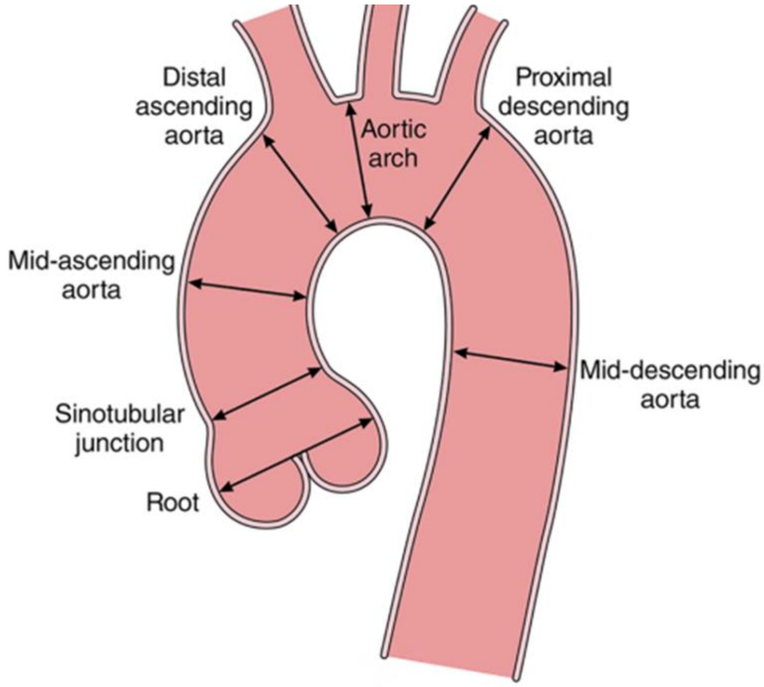
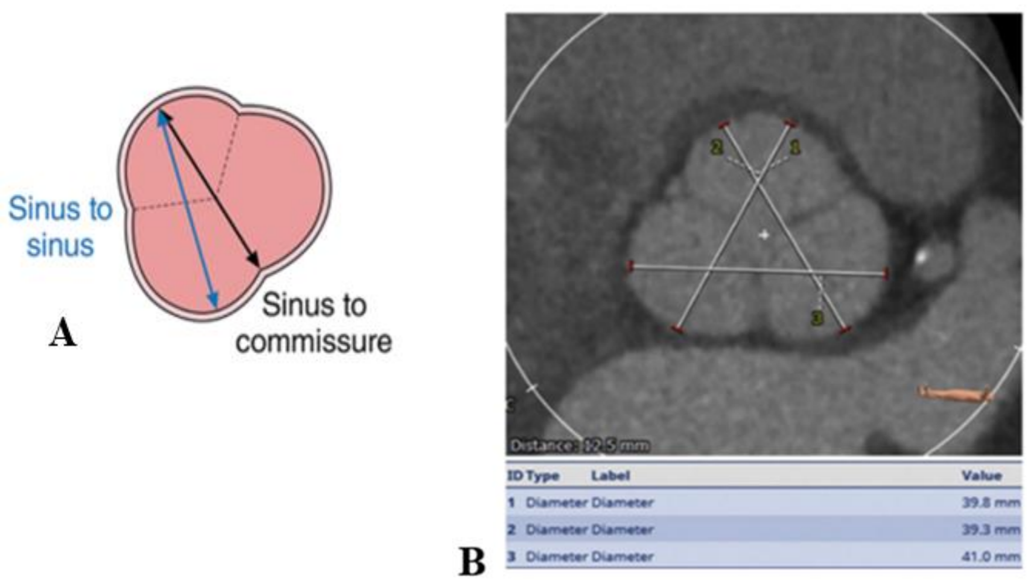


Figure 2: Sinus Measurement (A) Schematic showing the sinus-to-commissure and sinus-to-sinus measurements used for sinus of Valsalva measurement. (B) Coned contrast-enhanced axial CT of the TA sinus displaying sinus-to-sinus diameters that can be measured [3,4].



3. Objective

3.1 General objectives

This study aims to assess the diameter of the thoracic aorta (TA) at multiple anatomical levels and identify factors correlated with its diameter in adult Ethiopians who visited the Radiology Department at Tikur Anbessa Specialized Hospital between September 1 and November 30, 2024.

3.2 Specific objectives

1. To assess the diameter of the TA at eight anatomic levels using contrast-enhanced chest CT scans in adult Ethiopians who visited the Radiology Department at Tikur Anbessa Specialized Hospital from September 1 to November 30, 2024.

2. To identify factors correlated with the diameter of the TA in adult Ethiopians who visited the Radiology Department at Tikur Anbessa Specialized Hospital between September 1 and November 30, 2024.

4. Methods

4.1 Study setting and period

The study was conducted at Tikur Anbessa Specialized Hospital (TASH), the largest and oldest public specialized hospital in Ethiopia, which provides diagnosis and treatment to approximately 370,000 to 400,000 patients annually from various regions of the country. It is one of the primary centers in Ethiopia offering vascular surgery services. TASH also serves as a teaching hospital for Addis Ababa University's College of Health Sciences, playing a crucial role as a training center for undergraduate, specialty, and subspecialty programs for students from across Ethiopia and the Horn of Africa.

The research was conducted using data collected from September 1, 2024, to November 30, 2024.

4.2 Study design

An institution-based prospective cross-sectional study was conducted from September 1, 2024, to November 30, 2024.

4.3 Source population

The source population consisted of all adult patients referred from any unit of TASH to the radiology department for a contrast-enhanced chest CT scan between September 1, 2024, and November 30, 2024.

4.4. Study population

The study included all adults aged 18 years and older who were referred to the TASH radiology department for a contrast-enhanced chest CT scan between September 1, 2024, and November 30, 2024, with no exclusion criteria.

4.4.1 Exclusion criteria

- ✓ Aortic disease (e.g., aortic aneurysm, dissection, stenosis, or aortitis)
- ✓ Bicuspid aortic valve
- ✓ If a thoracic mass compresses the TA
- ✓ Not of Ethiopian descent

- ✓ Refusal to participate in the study
- ✓ If the CT scan image quality is not reportable

4.5 Sample size

The sample size were calculated based on infinite population taking P value as 50% (0.50) and Z=1.96 taking CI of 95%, d=0.05

Sample size will be determine by using the formula for

$$n = \frac{Z^2 P\,(1-P)}{d^2}$$

Where n : sample size

Z : Statistic for a level of confidence

P : Expected prevalence or proportion

d : Margin of error

$$n = \frac{(1.96)^2 0.5(1-0.5)}{0.05^2}$$

n =384

A consecutive sampling method was used to select study populations.

4.6 Operational definition.

- Sinus of Valsalva diameter: refers to the maximum diameter of the aortic root at sinus of Valsalva using sinus-to-sinus measurement.
- Sinotubular diameter: refers to the maximum diameter of the ATA from the outer-to-outer layer at the sinotubular junction.
- Mid-ATA diameter: refers to the maximum diameter of the ATA from the outer-to-outer layer at a midpoint between the sinotubular junction and distal ATA.
- Distal ATA diameter: refers to the maximum diameter of the ATA from the outer-to-outer layer just proximal to the origin of the brachiocephalic trunk.

- Mid aortic arch diameter: refers to the maximum diameter of the aortic arch from the outer-to-outer layer just distal to the left common carotid artery.
- Proximal DTA diameter: refers to the maximum diameter of the DTA from the outer-to-outer layer at 2cm distal to the left subclavian artery
- Mid-DTA diameter: refers to the maximum diameter of the DTA from the outer-to-outer layer at a midpoint between proximal DTA and distal DTA.
- Distal DTA diameter: refers to the maximum diameter of the DTA from the outer-to-outer layer at the diaphragm (2cm above celiac axis origin).
- Hypertension: Systolic blood pressure (SBP) ≥140 mm Hg, diastolic blood pressure (DBP) ≥ 90 mm Hg, or self-reported hypertension with the use of anti-hypertensive medications.
- Positive smoking status: refers to a patient who is currently smoking or has a history of smoking.
- Diabetes mellitus: If the patient carried an established diagnosis of diabetes mellitus made by a physician and/or is receiving treatment with insulin or oral hypoglycemic agents, or if their measured fasting glucose was 126 mg/dl.

4.7 Study variables

4.7.1 Independent variables

- Age
- Sex
- Height
- Weight
- Body surface area
- Body mass index
- Hypertension
- Diabetes mellitus
- Smoking

4.7.2 Dependent variables

- Thoracic Aorta diameter at different levels

4.8 Data collection procedures

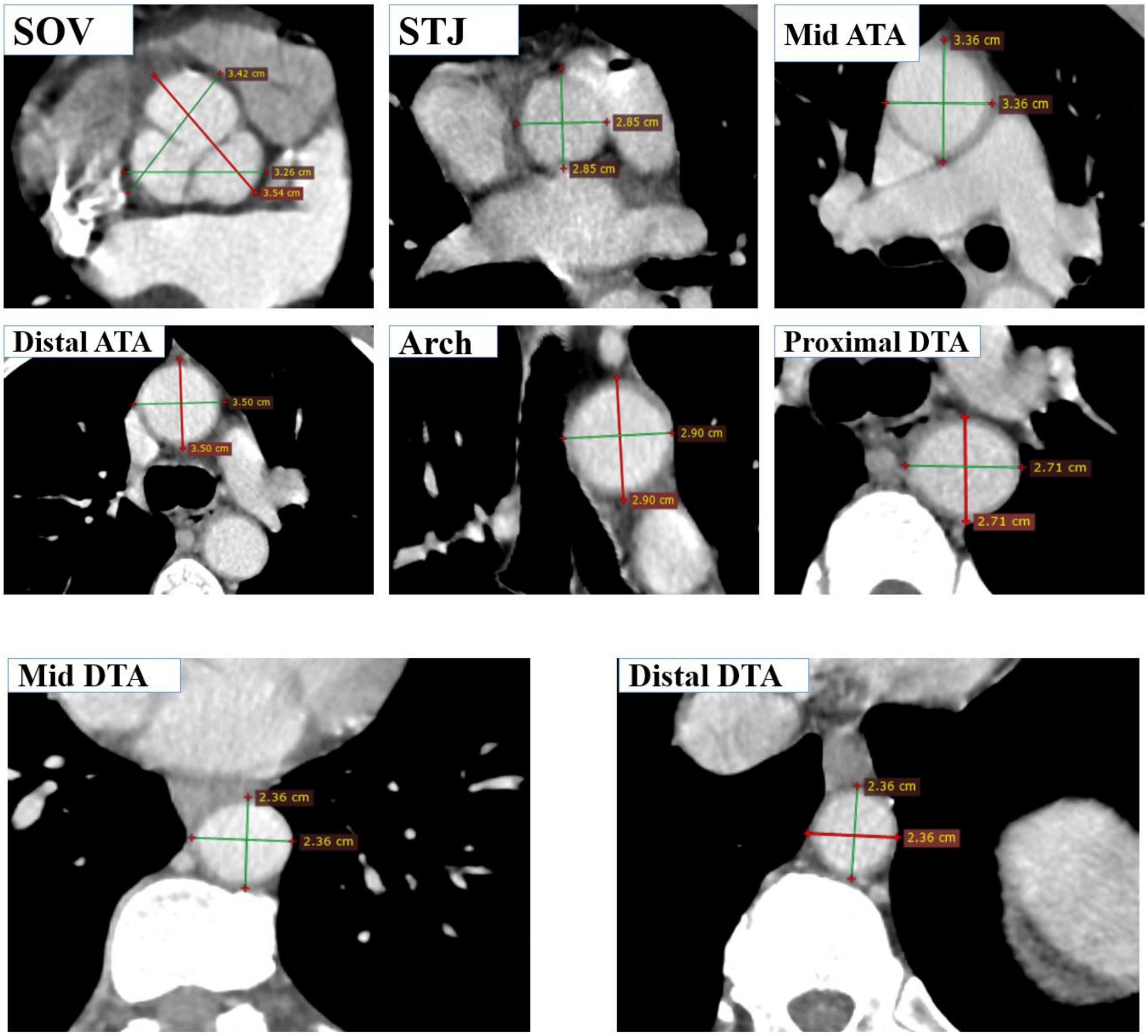
A prospective cross-sectional study was conducted at TASH from September 1st, 2024, to November 30th, 2024. A total of 398 participants were recruited for the study using a consecutive sampling technique. After informing the participants about the study and obtaining their willingness to participate, those who provided oral consent were included. All participant records were kept strictly confidential.

The participants were interviewed face-to-face by two trained nurses, under the close supervision of the primary investigator. During the interviews, demographic information such as age and gender, as well as clinical information including hypertension, diabetes mellitus (DM), and smoking history, were collected (clinical history was then verified by checking their medical records). Height was measured in centimetre (cm) using a stadiometer, and weight was measured in kilograms (kg) using a digital bathroom weighing scale. BMI was calculated in kg/m^2, and BSA was calculated using the Mosteller Formula: $BSA = 0.016667 \times W^{0.5} \times H^{0.5}$ (where W = weight and H = height).

A contrast-enhanced chest CT scan was performed using a GE optima CT 64-slice CT scanner after the intravenous administration of low-osmolar contrast media, based on the patient's clinical indication. To minimize motion artifacts, the patient was instructed to take a full breath and hold it for 1 second during the real-time scanning. A slice thickness of 5 mm was used for the volume scan, which was then reconstructed into coronal and sagittal planes with slice thicknesses ranging from 1 to 3 mm. The images were sent to the PACS (Picture Archiving and Communication System) workstation and reviewed by the investigators.

The thoracic aorta diameter was measured at eight levels: the sinus of Valsalva, STJ, mid-ATA, distal ATA, AA, proximal DTA, mid-DTA, and distal DTA, as defined in the operational definition. For each aortic level, the slices were manually adjusted to obtain an oblique plane that was strictly perpendicular to the course of the aorta. Measurements were taken from wall to wall (outer to outer) along the vessel's axis (Figure 3). All measurements were performed by the cardiothoracic imaging fellow. Of the 398 CTs reviewed, 12 were ineligible due to TA dilatation and aneurysm (n=6), coarctation (n=1), and significant motion artifact (n=5). Ultimately, 386 cases were selected for analysis.

Figure 3: Axial image taken at the eight levels of thoracic aorta. .



SOV: Sinus of Valsalva, STJ: Sinotubular Junction, ATA: Ascending thoracic aorta DTA: Descending Thoracic Aorta.

4.9 Data analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 27.0 for Microsoft Windows. Descriptive statistics, including frequency, percentages, mean, and ratios, were used to describe the demographic, anthropometric, and clinical data. Pearson correlations were applied to calculate associations between TA diameter and age, weight, height, BSA, and BMI at each level of aortic measurement. An independent Student's t-test was used to assess the association between gender and TA diameter, while the Mann-Whitney U test was used to assess the statistical significance of the correlation between hypertension, DM, and smoking with TA diameters at each level. A P-value of less than 0.05 was considered statistically significant.

4.10 Ethical consideration

Ethical clearance was obtained from the department's Research and Ethics Committee to carry out the study. The collected data was only used for this particular study and kept confidential.

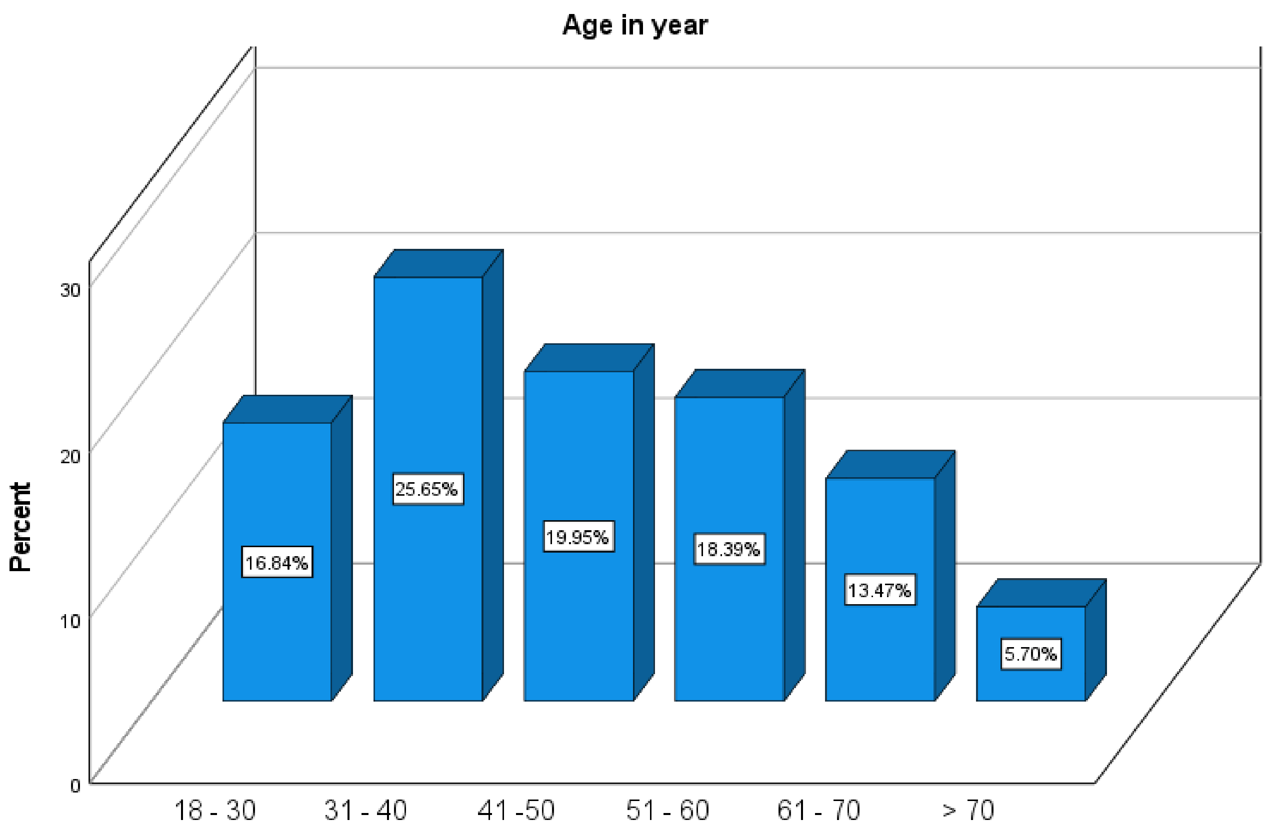
4.11 Dissemination and utilization of results

The results of the study will be submitted to the Department of Radiology and Vascular Surgery at Addis Ababa University and, in the future, will be submitted to an international peer-reviewed journal for publication.

5. Result

A total of 386 study population included in the study, including 244 (63.2%) females and 142 (36.8%) males, resulting in a male-to-female ratio of 1:1.72. The participants' ages ranged from 18 to 86 years, with the mean (±SD) age of the total study population being 46.04±15.39 years (45.92± 14.6 for females and 46.25± 16.72 for males). The largest age group was 31-40 years, comprising 25.65% of the study population, followed by the 41-50 year age group at 19.95% (Figure 4).

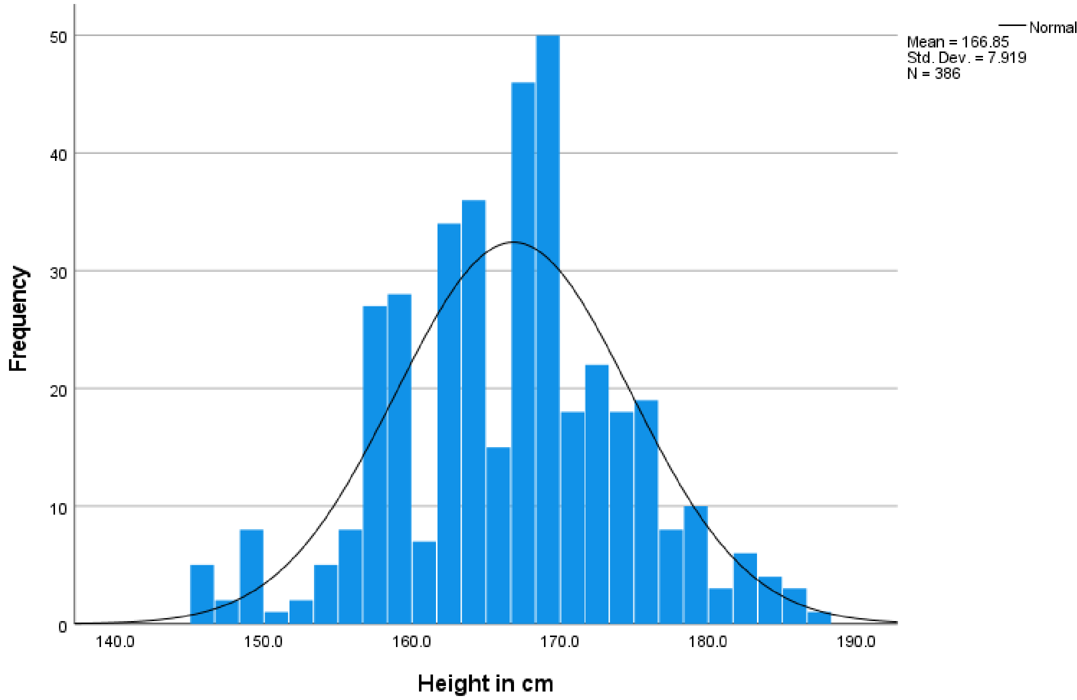
Figure 4: Age distribution of the study population.



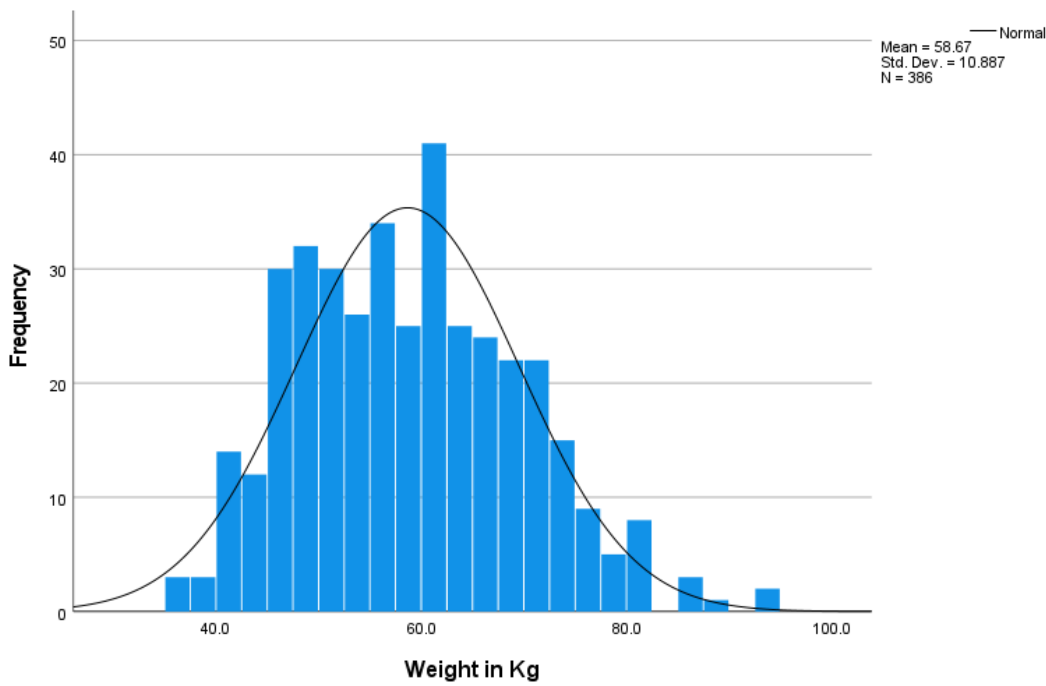
The study populations' heights ranged from 145 cm to 188 cm, with a mean (±SD) height of 166.85 ± 7.92 cm. Their weights varied between 37 kg and 94.2 kg, with a mean (±SD) of 58.67 ± 10.89 kg (Figure 5). BMI values ranged from 13.30 kg/m² to 33.80 kg/m², with a mean (±SD) of 21.1 ± 3.84 kg/m². The majority of the study participants (229, 59.33%) had a normal BMI, while only 9 (2.3%) were obese (Figure 6).

The participant's minimum and maximum BSA were 1.24 m² and 2.19 m², respectively, and the mean (±SD) was 1.64 ± 0.17 m².

Figure 5: Distribution of height (A) and weight (B) of the study population.

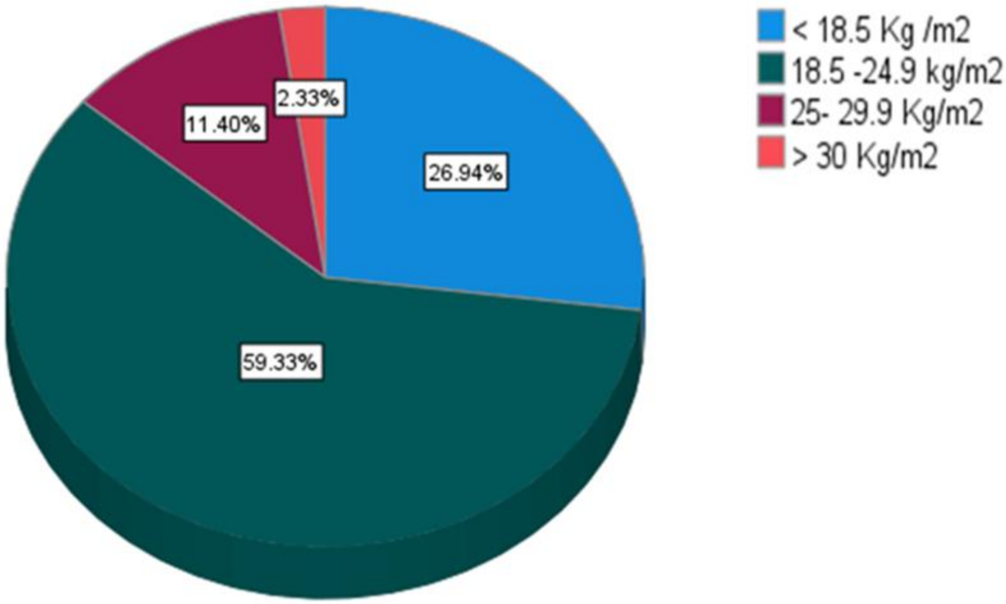


A



B

Figure 6: Distribution of Body Mass Index (BMI) in the study population.



In this study, 62 (16.1%), 28 (7.3%), and 13 (3.4%) of the patients had hypertension, diabetes mellitus (DM), and a history of smoking.

The maximum cusp to cusp diameter at the sinus of Valsalva of the aorta ranged from 29.10mm to 40mm with a mean (± SD) of 35.29 ± 2.6 mm and at the level of STJ, the minimum and the maximum diameter were 19mm and 36.1mm with a mean (± SD) of 27.1 ±2.71mm. The mean (± SD) diameter of the aorta at the level of mid-ATA, distal-ATA, arch, proximal, mid, and distal DTA were 33.72±3.35mm, 32.35 ± 3.29mm, 29.42 ± 2.82mm,26.66 ± 2.89mm, 23.42 ± 2.49mm and 21.80 ± 2.40mm, respectively (Table 1and 2).

The data showed male have higher mean thoracic aorta diameter than females at all measured levels, and the independent samples t test showed the presence of statically significant difference at sinus Valsalva , STJ, arch , proximal , mid and distal DTA level ($p<0.05$) (Table 2 and 3).

Table 1: The Minimum, maximum, mean and diameters and standard deviation of the TA at different anatomic levels.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
SOV	386	29.10	40.00	35.29	2.60
STJ	386	19.00	36.10	27.10	2.71
Mid ATA	386	23.00	39.90	33.72	3.35
Distal ATA	386	22.80	39.20	32.35	3.29
Arch	386	21.00	37.80	29.42	2.82
Proximal DTA	386	19.10	34.60	26.65	2.89
Mid DTA	386	16.20	30.20	23.42	2.49
Distal DTA	386	15.60	28.40	21.80	2.40
Valid N (listwise)	386				

ATA: Ascending Thoracic Aorta, DTA: Descending Thoracic Aorta, SOV: Sinus Of Valsalva, STJ: Sinotubular junction STJ.

Table 2 : Mean diameter of the TA at eight levels categorized by sex.

Level	Male (n=142) Mean ± SD (mm)	Female (n= 246) Mean± SD (mm)	Total (n = 386) Mean± SD (mm)
SOV	36.18±2.67	34.77±2.42	35.29 ± 2.6
STJ	27.79±3.06	26.70±2.40	27.10 ±2.71
Mid ATA	33.94±3.66	33.59±3.15	33.72±3.35
Distal ATA	32.71±3.59	32.14±3.10	32.35 ± 3.29
Aortic arch	29.87±3.10	29.16±2.62	29.42 ± 2.82
Proximal DTA	27.31±3.12	26.27±2.67	26.66 ±2.89
Mid DTA	24.14±2.62	23.00±2.31	23.42 ± 2.49
Distal DTA	22.47±2.72	21.42 ±2.11	21.80 ± 2.40

ATA: Ascending Thoracic Aorta, DTA: Descending Thoracic Aorta, SOV: Sinus of Valsalva, STJ: Sinotubular junction STJ.

Table 3 : Summary of the independent samples t-test between TA diameter at different anatomic levels and sex of study population.

Independent Samples Test

		Levene's Test for Equality of Variances			t-test for Equality of Means			
							95% Confidence Interval of the Difference	
		T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SOV	Equal variances assumed	-5.329	384	.000	-1.41208	.26500	-1.93312	-.89105
	Equal variances not assumed	-5.192	272.040	.000	-1.41208	.27195	-1.94748	-.87668
STJ	Equal variances assumed	-3.883	384	.000	-1.08937	.28055	-1.64097	-.53778
	Equal variances not assumed	-3.641	241.143	.000	-1.08937	.29921	-1.67877	-.49998
Mid-ATA	Equal variances assumed	-.986	384	.325	-.34857	.35347	-1.04354	.34641
	Equal variances not assumed	-.948	260.430	.344	-.34857	.36781	-1.07283	.37569
Distal ATA	Equal variances assumed	-1.646	384	.101	-.57005	.34632	-1.25097	.11087
	Equal variances not assumed	-1.582	260.373	.115	-.57005	.36040	-1.27971	.13961
Arch	Equal variances assumed	-2.409	384	.016	-.71287	.29587	-1.29459	-.13114
	Equal variances not assumed	-2.308	257.655	.022	-.71287	.30892	-1.32120	-.10453
Proximal DTA	Equal variances assumed	-3.462	384	.001	-1.03979	.30037	-1.63036	-.44922
	Equal variances not assumed	-3.324	259.667	.001	-1.03979	.31284	-1.65582	-.42375
Mid DTA	Equal variances assumed	-4.472	384	.000	-1.14659	.25637	-1.65067	-.64252
	Equal variances not assumed	-4.326	265.839	.000	-1.14659	.26504	-1.66843	-.62476
Distal DTA	Equal variances assumed	-4.225	384	.000	-1.04946	.24840	-1.53785	-.56106

Equal variances not assumed	-3.958	240.568	.000	-1.04946	.26513	-1.57173	-.52719

ATA: Ascending Thoracic Aorta, DTA: Descending Thoracic Aorta, SOV: Sinus Of Valsalva, STJ: Sinotubular junction STJ.

A statistically significant positive correlation was detected between participants' age and the diameter of the TA at all measured levels (Tables 4 and 5). Additionally, a statistically significant positive correlation was observed between the weight and BSA of the participant with the TA diameter at all levels (Table 5). There was also a statistically significant correlation found between height and TA diameters, except for the mid-DTA. A similarly significant correlation was noted for BMI, except at the sinus Valsalva and STJ levels ($p<0.05$) (Table 5).

Table 4: Mean diameter of the thoracic aorta at eight levels categorized by age.

	Age in year					
	18 – 30	31 - 40	41 -50	51 - 60	61 - 70	> 70
	Mean(mm)	Mean(mm)	Mean(mm)	Mean(mm)	Mean(mm)	Mean(mm)
SOV	33.61	34.69	35.22	36.34	36.21	37.64
STJ	25.27	26.49	27.50	27.85	27.85	29.60
Mid ATA	29.97	33.01	34.16	34.95	36.00	37.07
Distal ATA	28.67	31.63	32.93	33.62	34.24	35.93
Arch	26.53	28.61	29.87	30.56	31.06	32.45
Proximal DTA	23.65	25.77	27.19	27.91	28.34	29.62
Mid DTA	20.83	22.49	23.84	24.69	24.95	26.07
Distal DTA	19.23	20.79	22.26	23.17	23.30	24.45

ATA: Ascending Thoracic Aorta, DTA: Descending Thoracic Aorta, SOV: Sinus Of Valsalva, STJ: Sinotubular junction STJ.

Table 5: Correlation of thoracic aorta diameter at different anatomic levels with age, height, weight, body mass index (BMI), and body surface area (BSA).

Correlations

		Age	Height	Weight	BMI	BSA
SOV	Pearson Correlation	.433**	.276**	.180**	.045	.234**
	Sig. (2-tailed)	.000	.000	.000	.374	.000
	N	386	386	386	386	386
STJ	Pearson Correlation	.404**	.225**	.175**	.066	.216**
	Sig. (2-tailed)	.000	.000	.001	.193	.000
	N	386	386	386	386	386
Mid ATA	Pearson Correlation	.597**	.099	.209**	.167**	.217**
	Sig. (2-tailed)	.000	.052	.000	.001	.000
	N	386	386	386	386	386
Distal ATA	Pearson Correlation	.588**	.141**	.222**	.161**	.239**
	Sig. (2-tailed)	.000	.006	.000	.002	.000
	N	386	386	386	386	386
Arch	Pearson Correlation	.575**	.214**	.263**	.165**	.293**
	Sig. (2-tailed)	.000	.000	.000	.001	.000
	N	386	386	386	386	386
Proximal DTA	Pearson Correlation	.590**	.234**	.292**	.184**	.323**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	386	386	386	386	386
Mid DTA	Pearson Correlation	.622**	.306**	.331**	.183**	.377**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	386	386	386	386	386
Distal DTA	Pearson Correlation	.650**	.303**	.303**	.154**	.352**
	Sig. (2-tailed)	.000	.000	.000	.002	.000
	N	386	386	386	386	386

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

ATA: Ascending Thoracic Aorta, DTA: Descending Thoracic Aorta, SOV: Sinus Of Valsalva, STJ: Sinotubular junction STJ.

The study also found that participants with a history of hypertension and diabetes mellitus (DM) had a larger thoracic aorta size compared to participants without these histories (Table 6). The Mann-Whitney U test was used to assess the significance of these findings since these variables didn’t have normal distribution (negatively skewed). We found that, at all TA levels, patients with hypertension had a larger mean diameter than study participants without a history of hypertension ($p < 0.05$) (Table 7). However, for DM, statistically significant differences were noted at the sinus of Valsalva, mid ATA, proximal, mid, and distal DTA ($p < 0.05$)(Table 8).

Table 6: Mean diameter of the thoracic aorta categorized by history of hypertension and Diabetes Mellitus (DM) at different levels.

	Mean							
Hypertension	SOV	STJ	Mid-ATA	Distal ATA	Arch	Proximal DTA	Mid DTA	Distal DTA
Yes	35.93	28.41	35.97	34.31	30.84	27.93	24.65	22.91
No	35.17	26.85	33.29	31.98	29.14	26.41	23.185	21.59
DM								
Yes	36.43	27.57	35.02	33.18	30.18	27.69	24.60	22.86
No	35.20	27.06	33.62	32.29	29.36	26.58	23.33	21.72

ATA: Ascending Thoracic Aorta, DTA: Descending Thoracic Aorta, SOV: Sinus of Valsalva, STJ: Sinotubular junction STJ.

Table 7: Mann-Whitney U test comparing thoracic aorta diameters at different anatomic levels based on the presence or absence of hypertension.

Test Statistics

	SOV	STJ	Mid ATA	Distal ATA	Arch	Proximal DTA	Mid DTA	Distal DTA
Mann-Whitney U	8447.500	6927.500	5294.500	5866.500	6066.000	6648.000	6474.500	6732.500
Wilcoxon W	61097.500	59577.500	57944.500	58516.500	58716.000	59298.000	59124.500	59382.500
Z	-1.984	-3.873	-5.902	-5.191	-4.944	-4.220	-4.435	-4.115
Asymp. Sig. (2-tailed)	.047	.000	.000	.000	.000	.000	.000	.000

a. Grouping Variable: History of hypertension

Table 8: Mann-Whitney U test comparing thoracic aorta diameters at different anatomic levels based on the presence or absence of Diabetes Mellitus (DM).

Test Statistics

	SOV	STJ	Mid ATA	Distal ATA	Arch	Proximal DTA	Mid DTA	Distal DTA
Mann-Whitney U	3617.500	4592.000	3739.000	4227.000	3962.000	3888.500	3493.500	3724.500
Wilcoxon W	67878.500	68853.000	68000.000	68488.000	68223.000	68149.500	67754.500	67985.500
Z	-2.453	-.739	-2.239	-1.381	-1.847	-1.976	-2.671	-2.265
Asymp. Sig. (2-tailed)	.014	.460	.025	.167	.065	.048	.008	.024

a. Grouping Variable: History of DM

Similarly, the study revealed that patients with a smoking history had a larger diameter than non-smokers at all levels. Since the data were negatively skewed, the Mann-Whitney U test was used, and statistically significant differences were observed only at the levels of the SOV, STJ, mid, and distal DTA ($p < 0.05$)(Table 9).

Table 9: Mann-Whitney U test between thoracic aorta diameters at different anatomic levels based on the presence or absence of smoking.

Test Statistics

	SOV	STJ	Mid-ATA	Distal ATA	Arch	Proximal DTA	Mid DTA	Distal DTA
Mann-Whitney U	1281.500	1554.000	1992.000	1919.500	1826.000	2177.500	1634.000	1540.500
Wilcoxon W	71032.500	71305.000	71743.000	71670.500	71577.000	71928.500	71385.000	71291.500
Z	-2.891	-2.202	-1.094	-1.277	-1.514	-.625	-1.999	-2.236
Asymp. Sig. (2-tailed)	.004	.028	.274	.202	.130	.532	.046	.025

a. Grouping Variable: History of smoking

6. Discussion

Three hundred and eighty-six (386) subjects participated in the study, and the mean (±SD) diameters at various levels of the thoracic aorta (TA) were as follows: sinus of Valsalva (35.29 ± 2.6 mm), STJ (27.1 ± 2.71 mm), mid-DTA (33.72 ± 3.35 mm), distal DTA (32.35 ± 3.29 mm), aortic arch (29.42 ± 2.82 mm), proximal DTA (26.66 ± 2.89 mm), mid-DTA (23.42 ± 2.49 mm), and distal DTA (21.80 ± 2.40 mm). The data indicate a clear trend in the dimensions of the thoracic aorta, with the widest diameter observed at the sinus of Valsalva. As the aorta moves distally, particularly after the mid-ATA, it shows smooth tapering. This pattern aligns with previous research[14,15,18,21,23–25,29]. This reduction in diameter can be attributed to the notable shift in the elastin and collagen ratios as one moves from the proximal to the distal TA [18].

In the study conducted by Ahmed Shehata et al. in Egypt, the TA mean (± SD) diameters were as follows: 33.75 ± 3.93 mm at the sinus, 26.13 ± 3.05 mm at the STJ, 30.97 ± 4.16 mm at the ATA (maximum diameter at the tubular part of the ATA), 24.17 ± 2.92 mm at the pulmonary bifurcation level of the DTA, and 21.94 ± 2.73 mm at the diaphragmatic level of the DTA. The diameters in this study are smaller than ours at the SOV, STJ, and ATA by 1.54 mm, 0.97 mm, and 2.75 mm, respectively. However, they are larger by 0.74 mm and 0.14 mm at the mid and distal DTA levels, respectively. This study used ECG-gated cardiac CT, with diameters measured during the systolic (40%) and diastolic (75%) phases of the cardiac cycle, and the mean of the systolic and diastolic diameters were calculated. In contrast, our study used non-ECG-gated chest CT, and phase differences were not considered. In the Ahmed Shehata study, the measurements at the aortic sinus and STJ were taken from the hinge-to-hinge distance (from the outer upper side to the inner lower side), whereas for the ATA, inner-to-inner diameters were used. In our study, outer-to-outer measurements were taken [14].

Our study showed a comparable mean diameter at the ATA and arch when compared to the study conducted by Abdullahi Shuaibu in Nigeria (34.53 ± 5.23 mm at the ATA and 29.73 ± 4.89 mm at the DTA). However, the diameter at the DTA in our study was smaller (23.42 ± 2.49 mm vs. 27.17 ± 4.62 mm), by 3.75 mm. This difference can be explained by the larger mean weight and BSA of the participants in their study (66.68 kg and 1.72 m², respectively) [15].The study conducted by Arik Wolak found that the mean diameter of TA at the mid ATA and mid DTA were 33mm and 24mm, respectively. When compared to our results, our diameter is only larger by 0.72mm at the mid ATA and smaller by 0.58mm at the mid DTA level[22].

When we compare the mean TA diameters at the SOV, mid ATA, distal ATA, and arch levels with the study conducted by Alfred Hager et al. in Germany, our mean diameters are larger by 5.49 mm, 2.82 mm, 2.95 mm, and 1.72 mm, respectively. This difference may be attributed to the measurement technique used in the studies; they employed an inner-to-inner measurement method[18].Similarly, when compared to the study conducted by Juntima Euathrongchit and colleagues on Thai people, the mean TA diameters at the distal ATA, arch, proximal, mid, and distal DTA are larger in our study by 2.85mm, 3.52mm, 3.35mm, 2mm, and 1.5mm, respectively. This difference can be explained by the exclusion of patients with hypertension and diabetes mellitus (DM) in their study, unlike ours [21].The study conducted by Hyoung Woo Chang and his colleagues in Korea also found smaller TA diameters at the sinus of Valsalva, arch, and mid DTA compared to our study, by 0.39mm, 1.42mm, and 1.38mm, respectively. This can be attributed to the smaller study population weight in their study and the use of the inner-to-inner measurement method[25].

Our study revealed that males have a slightly larger mean TA diameter than females at all levels. However, the independent samples t-test showed a statistically significant difference in diameters between sexes at the sinus Valsalva, STJ, arch, proximal, mid, and distal DTA levels ($p < 0.05$) (Table 3). These findings are consistent with studies conducted by Alfred Hager, Juntima Euathrongchit, and Arik Wolak.[18,21,22].

We found a statistically significant positive correlation between age and TA diameter at all levels (Tables 4 and 5). The maximum values of thoracic aortic diameter were observed in older age groups, with increasing diameters detected as the age of the participants increased. These results are consistent with findings from most other studies in the literature.[14,18,21,22,24,25].

Our study also showed a statistically significant positive correlation between BSA and mean diameter measurements at all TA levels (Table 5), similar to the study conducted by Arik Wolak, Abdullahi Shuaibu, and Fay Y. Lin[15,22,23]. Additionally, we found a statistically significant positive correlation between the weight of the study population and the mean diameter at all TA levels, similar to the findings of Abdullahi Shuaibu[15].

Similar to the study conducted by Arilk Wolak and Ahmed Shehata, our study showed a statistically significant positive correlation between the TA diameters at all levels and the presence of hypertension [14,22].

The study population with DM showed a statistically significant larger mean diameter at the Sinus of Valsalva, mid ATA, proximal, mid, and distal DTA ($p < 0.05$) (Table 8) compared to those with no history of DM. The statistically significant correlation observed at the ATA in our study is consistent with the study conducted by Arik Wolak, although the correlation at the DTA was not observed in their study. We also found a statistically significant positive correlation between the history of smoking and TA diameter at the level of the SOV, STJ, mid-DTA, and distal DTA (Table 9), which is consistent with the positive correlation observed at the DTA in the study conducted by Arik Wolak [22].

7. Strengths and Limitations of the Study

Strength of the study: To the best of our knowledge, this is the first study conducted in Ethiopia and can serve as a foundation for future research. The study was carried out at one of the largest hospitals in the country, where patients came from various regions across Ethiopia.

Limitations: Since this study was conducted at a single institution, it may not accurately reflect the size of the thoracic aorta in the general population. The imaging was non-electrocardiogram (ECG)-gated.

8. Conclusion

This study provides preliminary reference data on thoracic aortic (TA) diameters at different levels in the Ethiopian population, which will assist in selecting the appropriate size of thoracic devices for interventions. The TA diameters observed in this study vary compared to those from other countries, likely due to differences in measurement methods and the anthropometric characteristics of the populations. Nevertheless, factors such as age, weight, body surface area (BSA), and hypertension demonstrated a significant positive correlation with the TA diameter, consistent with findings in existing literature.

9. Recommendation

The authors recommend conducting a large-scale, multicenter study to address regional and ethnic differences.

10. Reference

1. Booher AM, Tsai TT. Thoracic Aortic Diseases. *Inpatient Cardiovascular Medicine* 2013; 138–153.

2. Vincent B. Ho, MD, MBA F, Gautham P. Reddy, MD M. *Cardiovascular Imaging: Expert Radiology Series*. 2011.

3. Isselbacher EM, Preventza O, Black JH, et al. 2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease: A Report of the American Heart Association/American College of Cardiology Joint Committee on Clinical Practice Guidelines. *Circulation* 2022; 146: E334–E482.

4. Elefteriades JA, Mukherjee SK, Mojibian H. Discrepancies in Measurement of the Thoracic Aorta: JACC Review Topic of the Week. *Journal of the American College of Cardiology* 2020; 76: 201–217.

5. Bhave NM, Nienaber CA, Clough RE, et al. Multimodality Imaging of Thoracic Aortic Diseases in Adults. *JACC: Cardiovascular Imaging* 2018; 11: 902–919.

6. Calhoun PS, Kuszyk BS, Heath DG, et al. Three-dimensional volume rendering of spiral CT data: Theory and method. *Radiographics* 1999; 19: 745–764.

7. Carrero MC, Matta MG, Masson GG, et al. Gender-related differences in aortic diameters: why do we use the same cutoff? *Eur Hear J - Cardiovasc Imaging* 2023; 24: 281–283.

8. Michael E. Barfield, MD, and Thomas S. Maldonado M. Identifying the Appropriate Thoracic Device Size. *Vol 16 No 11* 2017; 16: 52.

9. Upchurch GR, Escobar GA, Azizzadeh A, et al. Society for Vascular Surgery clinical practice guidelines of thoracic endovascular aortic repair for descending thoracic aortic aneurysms. *J Vasc Surg* 2021; 73: 55S–83S.

10. Gryaznov AA, Ziganshin BA, Elefteriades JA. Time to Move to Earlier Intervention for Thoracic Aortic Aneurysm? *Struct Hear* 2018; 2: 10–22.

11. Roth GA, Mensah GA, Johnson CO, et al. Global Burden of Cardiovascular Diseases and

Risk Factors, 1990–2019: Update From the GBD 2019 Study. *J Am Coll Cardiol* 2020; 76: 2982.

12. Minja NM, Nakagaayi D, Aliku T, et al. Cardiovascular diseases in Africa in the twenty-first century: Gaps and priorities going forward. *Front Cardiovasc Med* 2022; 9: 1008335.

13. Isselbacher EM. Thoracic and abdominal aortic aneurysms. *Circulation* 2005; 111: 816–828.

14. Ismail ASM, Al-Suraimi SAM, El Hossary HEDG, et al. Multidetector computed tomography study to measure thoracic aorta diameters in Egyptian population. *Egypt Hear J*; 73(1).

15. Shuaibu A, Anakwue A-M, Mohammed S, et al. COMPUTED TOMOGRAPHIC DETERMINATION OF NORMAL REFERENCE VALUES FOR THORACIC AORTIC DIAMETER IN KADUNA STATE NIGERIA: A BASELINE STUDY. *FUDMA J Sci* 2024; 8: 281–288.

16. Schlatmann TJM, Becker AE. *Histologic Changes in the Normal Aging Aorta: Implications for Dissecting Aortic Aneurysm*. 1977.

17. Macris MP, Frazier OH. Diseases of the Thoracic Aorta. In: *Modern Surgical Care: Physiologic Foundations and Clinical Applications, Third Edition*. CRC Press, 2006, pp. 897–906.

18. Hager A, Kaemmerer H, Rapp-Bernhardt U, et al. Diameters of the thoracic aorta throughout life as measured with helical computed tomography. *J Thorac Cardiovasc Surg* 2002; 123: 1060–1066.

19. Koju A, Joshi BR. Assessment of the Diameter of Thoracic Aorta by Computed Tomography of Chest. *Nepal J Radiol* 2018; 8: 13–19.

20. Freeman LA, Young PM, Foley TA, et al. CT and MRI assessment of the aortic root and ascending aorta. *Am J Roentgenol*; 200,(2013).

21. Euathrongchit J, Deesuwan P, Kuanprasert S, et al. Normal thoracic aortic diameter in thai

people by multidetector computed tomography. *J Med Assoc Thail* 2009; 92: 236–242.

22. Wolak A, Gransar H, Thomson LEJ, et al. Aortic Size Assessment by Noncontrast Cardiac Computed Tomography: Normal Limits by Age, Gender, and Body Surface Area. *JACC Cardiovasc Imaging* 2008; 1: 200–209.

23. Lin FY, Devereux RB, Roman MJ, et al. Assessment of the thoracic aorta by multidetector computed tomography: Age- and sex-specific reference values in adults without evident cardiovascular disease. *J Cardiovasc Comput Tomogr* 2008; 2: 298–308.

24. Lee SH, Lee W, Choi HJ, et al. Measurement of the Aortic Diameter in the Asymptomatic Korean Population: Assessment with Multidetector CT. *J Korean Soc Radiol* 2013; 69: 105.

25. Chang HW, Kim SH, Hakim AR, et al. Diameter and growth rate of the thoracic aorta-analysis based on serial computed tomography scans. *J Thorac Dis* 2020; 12: 4002–4013.

26. Pokhrel S, Sharma R. Study on Assessment of the Diameter of Thoracic Aorta by Computed Tomography of Chest. *J KIST Med Coll* 2024; 6: 55–58.

27. Hamid A, Gupta M, Shantha P, et al. The current and future role of imaging of thoracic aortic disease : a North American society for cardiovascular imaging commentary on the 2022 AHA / ACC guidelines for the diagnosis and management of aortic disease. *Int J Cardiovasc Imaging* 2024; 40: 5–14.

28. Goldstein SA, Evangelista A, Abbara S, et al. Multimodality imaging of diseases of the thoracic aorta in adults: From the American society of echocardiography and the european association of cardiovascular imaging: Endorsed by the society of cardiovascular computed tomography and society for cardiova. *J Am Soc Echocardiogr* 2015; 28: 119–182.

29. Wolak A, Gransar H, Thomson LEJ, et al. Aortic Size Assessment by Noncontrast Cardiac Computed Tomography: Normal Limits by Age, Gender, and Body Surface Area. *JACC Cardiovasc Imaging* 2008; 1: 200–209.

11. ANNEX

11.1 ANNEX 1–Data Collection Checklist

I care number	
Age (yrs)	
Sex	
Height (cm)	
Weight (Kg)	
Height	
BMI	
BSA	
Hypertension	
Smoking	
Diabetes	
Cardiac Disease	
Chest CT findings, Maximum diameter (mm)	
Diameter at the sinus of Valsalva (maximum of sinus to sinus)	
Sinotubular junction	
Mid-ATA	
Distal ATA	
Aortic arch	
Proximal DTA	
Mid DTA	
Distal DTA	

11.2 ANEXX 2 – Assurance of investigator

I, Dr. Hawi Farris, declare that this paper is the result of my independent research work on the topic entitled "Assessment of Thoracic Aorta Diameters Using Contrast-Enhanced Chest Computed Tomography in Ethiopian Adults at Tikur Anbessa Specialized Hospital," in partial fulfillment of the requirements for a Sub-specialty Certificate in Cardiothoracic Imaging at Addis Ababa University, College of Health Sciences, Department of Radiology. This work has not been submitted to any other university, and all references have been duly acknowledged.

Dr. Hawi Farris

Signature ______________________

Date ________________________

Conformation

This is to certify that Dr. Hawi Farris has carried out this research work on the topic entitled "Assessment of Thoracic Aorta Diameters Using Contrast-Enhanced Chest Computed Tomography in Ethiopian Adults at Tikur Anbessa Specialized Hospital" under my supervision. This work is original, has not been presented at any university, and may be submitted in partial fulfillment of the requirements for the award of the Sub-specialty Certificate in Cardiothoracic Imaging, Addis Ababa University.

Dr. Azmera Gissila (MD, Assistant professor of radiology, Cardiothoracic imaging subspecialist)

Signature ________________

Date ___________________

Dr. Amir Alwan (MD, Assistant professor of radiology, cardiothoracic imaging subspecialist)

Signature _____________________

Date _____________________