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Measurement of Thoracic Aortic Diameter Using Contrast-Enhanced CT Chest Based on Age, Gender, and Hypertension

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ABSTRACT

Introduction: CT is widely used to evaluate patients with aneurysm or aortic dissection. Therefore, it is very important to assess accurate aortic size in detecting aneurysm and dissection. The thoracic aortic diameter varies depending on the measurement level. Several demographic factors affect the thoracic aorta diameter such as age and gender. Risk factors for cardiovascular disease such as hypertension also have a relationship with the diameter of the thoracic aorta. To determine the difference of thoracic aorta diameter based on age, sex, and history of hypertension in patients with contrast-enhanced CT chest.

Method: A case-control study in 140 patients with contrast-enhanced CT chest without signs or symptoms of cardiovascular diseases. Thoracic aortic diameters were measured at seven predetermined levels on CT images. Analysis of data was performed with regard to age, sex, and hypertension.

Results: The mean diameters of the thoracic aorta at the level of the aortic valve sinus is 3.06 ± 0.39 cm, ascending aorta 2.90 ± 0.39 cm, proximal to innominate artery 2.73 ± 0.39 cm, transverse aortic arch 2.53 ± 0.38, distal transverse aortic arch 2.37 ± 0.35, aortic isthmus 2.17 ± 0.33, and descending aorta at the level of diaphragm 1.91 ± 0.33 cm. There is a significant difference in all thoracic aortic diameters based on age and gender on statistical analysis ($p<0.001$). There is a significant difference in all thoracic aortic diameters between subjects with history of hypertension and without history of hypertension, except at the level of transverse aortic arch ($p<0.051$).

Conclusion: There is a difference in the mean thoracic aortic diameter at each level of measurement based on age, sex, and history of hypertension in patients with contrast-enhanced CT chest.

Keywords Thoracic aorta, Age, Gender, Hypertension

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INTRODUCTION

After the introduction of helical computed tomography (CT) in the late 1980s, the use of CT for aortic imaging has been widely practiced to detect aortic stenosis, aneurysm, or dissection formation.[1] Thoracic aortic aneurysms are less common than abdominal aortic aneurysms.[2] The incidence rate of combined thoracic aortic aneurysm and thoracic aortic dissection has been reported to be 6 to 13 per 100,000 per year, although this would underestimate clinically silent thoracic aortic aneurysm.[3]

An aortic aneurysm is common and has a lethal prognosis, but treatable disease, particularly if detected before dissection or rupture.[4] Most patients with thoracic aortic aneurysms are asymptomatic and are detected incidentally during thoracic imaging due to symptoms in other thoracic structures.[2] therefore, accurate assessment of aortic size is important in detecting aneurysms to guide therapeutic decisions. CT has been accepted as the mainstay modality for evaluating the thoracic aorta due to its accuracy and reproducibility, as well as its speed, simplicity, and true 3-dimensional capability.[4]

The normal size of the ascending aorta diameter is <3.5 cm and descending aorta <3 cm when measured using CT or MRI.[5] As measured on CT or MRI scans, the ascending aortic is normally <3.5 cm in diameter and the descending aortic is <3 cm.5 In general, the term aneurysm is used when the axial diameter of the ascending aorta is >5.0 cm and the descending aorta is >4.0 cm. When enlarged above normal values but not reaching the definition of the aneurysm, the term dilatation/ectasia may be used. All parts of the thoracic aorta may be affected by aneurysmal dilatation.[6] Thoracic aneurysms may involve one or more aortic segments. Sixty percent of thoracic aortic aneurysms involve the aortic root and/or ascending aortic, 40% involve the descending aortic 10% involve the arch, and 10% involve the thoracoabdominal aortic.[7]

CT has become the mainstay modality for evaluating the thoracic aorta, but publications on measuring aortic diameter are limited. To distinguish the normal from the enlarged thoracic aortic, it is necessary to standardize the values of “normal” thoracic aortic dimensions. But, to our knowledge, no publication up until now has reported on these aortic measurements in a population of Indonesian adults. The purposes of this study were to establish reference values of the thoracic aorta obtained by contrast-enhanced CT chest in asymptomatic Indonesian adults and to analyze the relationship between these values and age, sex, and hypertension.

METHOD

This study was a case-control study in patients who underwent contrast-enhanced CT chest at Departement of Radiology H. Adam Malik Hospital Medan from 2019-2022. Data collection has obtained permission from the Ethics Committee for the Implementation of Health Research, Faculty of Medicine, University of North Sumatra. The retrospective study was performed by searching lists of patients from the radiology report database. Thoracic aortic diameters were measured retrospectively in 140 consecutive Indonesian adults who underwent contrast-enhanced CT chest for a variety of non-vascular clinical problems.

Inclusion criteria were all patients referred for the contrast-enhanced CT chest in the Department of Radiology H. Adam Malik Hospital Medan and the age of the research subjects more than 18 years old. Exclusion criteria were patients having pathological changes such as, aortic aneurysm, aortic dissection, and aortic thrombus. Patients with history of diabetes mellitus were also excluded. The characteristics of patients are shown in Table 1.

Table 1. Characteristics of patients

Characteristics	**N**	**%**
Age		
≤ 60 years	70	50
> 60 years	70	50
Gender		
Male	70	50
Female	70	50
Hypertension		
Yes	30	21.4
No	110	78.6

CT examination was performed using *GE Bright Speed Elite 16 Slices*. CT was obtained with the patient in supine position during full inspiration. The scan range was from 1 cm above lung apices to the diaphragm. The exposure parameters were 120 kV, 225 mA, and a slice thickness of 3 mm.

The diameters of the aorta were measured at the levels of aortic valve sinus, ascending aorta, proximal to innominate artery, transverse aortic arch, distal transverse aortic arch, aortic isthmus and descending aorta at the level of diaphragm perpendicular to the axis of the blood flow in the aorta in the operator console of the

CT scanner. They used the sagittal slices to manually select each predefined aortic level. The aortic diameters were measured from the outer edge of the wall to the outer edge of the opposite wall. The internal diameter of the vessel was measured with an electronic caliper. All images were reconstructed and analyzed.

The data were collected in Microsoft Excel and were analyzed using SPSS program version 26. If the data were normally distributed, then statistical analysis used independent T-test. The abnormally distributed data statistical analysis used the Mann-Whitney test. Data reported as total number of each group (n) with statistical significance set a priori at $p<0.05$.

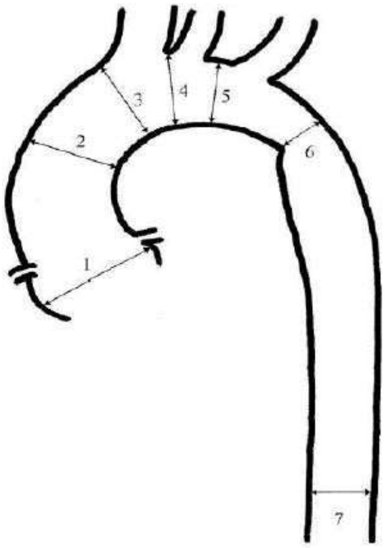

Figure 1. Levels of measurement aortic diameters: 1, Aortic valve sinus; 2, ascending aorta; 3, aorta proximal to innominate artery; 4, proximal transverse aortic arch; 5, distal transverse aortic arch; 6, aortic isthmus; 7, descending aorta at the level of diaphragm.

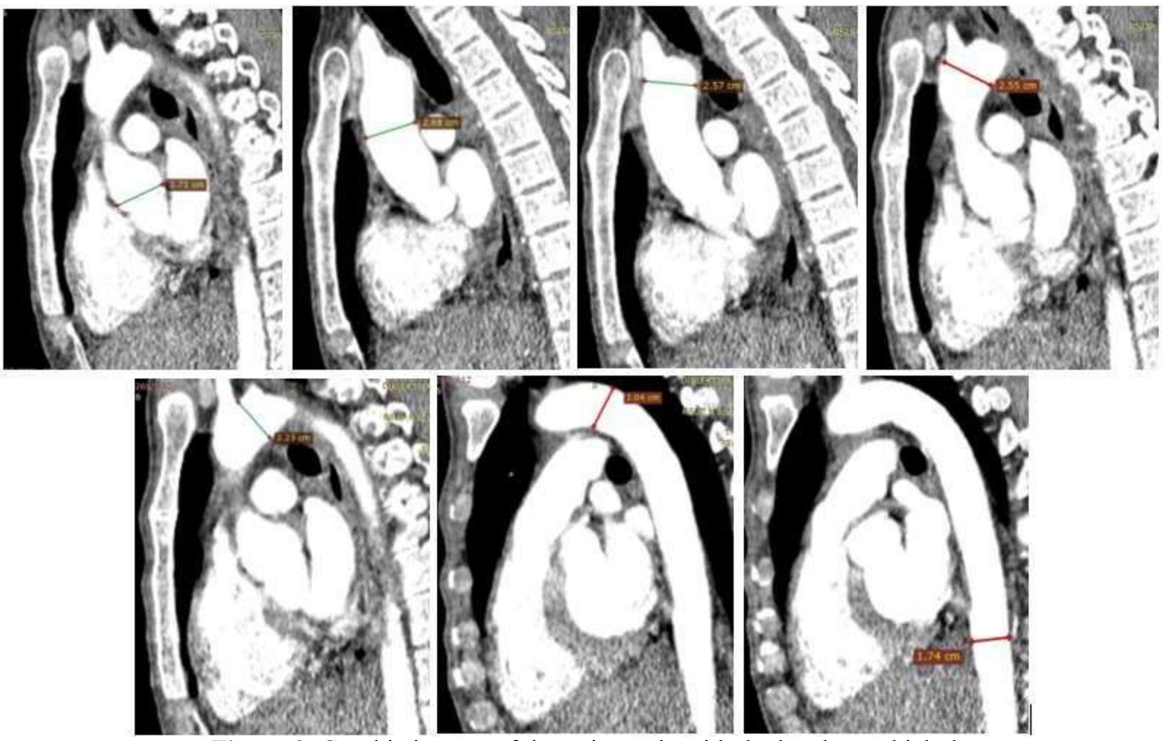

Figure 2. Graphic images of thoracic aortic with the levels at which the diameters were measured.

RESULTS

Aortic diameters (mean ± SD) had the following measurements: 3.06 ± 0.39 cm at aortic valve sinus, 2.90 ± 0.39 cm at ascending aorta, 2.73 ± 0.39 cm at proximal to innominate artery, 2.53 ± 0.38 at transverse aortic arch, 2.37 ± 0.35 at distal transverse aortic arch, 2.17 ± 0.33 at aortic isthmus, and 1.91 ± 0.33 cm at descending aorta at the level of diaphragm. Overall thoracic aortic diameters tend to continuously significantly decrease from proximal to distal.

The mean thoracic aortic diameters ± SD of the total 140 Indonesian adults of seven thoracic aortic levels were classified by gender, two age groups, and history of hypertension as shown in Table 2, Table 3, and Table 4, respectively.

Table 2. Measured thoracic aortic diameters of seven predetermined levels chest CT in 140 Indonesian adults by age

Measured thoracic aortic level	Age group ≤ 60 years (cm) Mean ± SD	> 60 years (cm) Mean ± SD	P*
Aortic valve sinus	2.81 ± 0.28	3.30 ± 0.32	<0.001
Ascending aorta	2.64 ± 0.29	3.15 ± 0.30	<0.001
Proximal to innominate artery	2.48 ± 0.29	2.98 ± 0.30	<0.001
Transverse aortic arch	2.26 ± 0.26	2.80 ± 0.29	<0.001
Distal transverse aortic arch	2.13 ± 0.27	2.61 ± 0.25	<0.001
Aortic isthmus	1.95 ± 0.23	2.38 ± 0.25	<0.001
Descending aorta at the level of diaphragm	1.69 ± 0.22	2.13 ± 0.26	<0.001

(*) Independent T-test

All diameters of thoracic aorta increased with age with statistical significance (p <0.001) on the independent T-test as shown in Table 2.

Table 3. Measured thoracic aortic diameters of seven predetermined levels chest CT in 140 Indonesian adults by gender

Measured thoracic aortic level	Gender group Male (cm) Mean ± SD	Female (cm) Mean ± SD	P
Aortic valve sinus	3.20 ± 0.38	2.91 ± 0.34	<0.001*
Ascending aorta	3.04 ± 0.36	2.76 ± 0.36	<0.001*
Proximal to innominate artery	2.86 ± 0.36	2.59 ± 0.37	<0.001*
Transverse aortic arch	2.66 ± 0.37	2.39 ± 0.35	<0.001*
Distal transverse aortic arch	2.48 ± 0.33	2.26 ± 0.34	<0.001**
Aortic isthmus	2.29 ± 0.30	2.05 ± 0.31	<0.001*
Descending aorta at the level of diaphragm	2.03 ± 0.33	1.78 ± 0.27	<0.001*

(*) Independent T-test; (**) Mann whitney test

Males had enlarged thoracic aortic diameters in all seven predefined levels, more than females with statistical significance (p<0.001) as shown in Table 3.

Table 4. Measured thoracic aortic diameters of seven predetermined levels chest CT in 140 Indonesian adults by hypertension

Measured thoracic aortic level	Hypertension group Yes (cm) Mean ± SD	No (cm) Mean ± SD	P
Aortic valve sinus	3.24 ± 0.38	3.00 ± 0.38	0.003*
Ascending aorta	3.09 ± 0.40	2.85 ± 0.37	0.002**
Proximal to innominate artery	2.85 ± 0.38	2.69 ± 0.39	0.026**
Transverse aortic arch	2.65 ± 0.38	2.49 ± 0.38	0.051**
Distal transverse aortic arch	2.50 ± 0.38	2.34 ± 0.34	0.026**
Aortic isthmus	2.29 ± 0.34	2.13 ± 0.31	0.018*
Descending aorta at the level of diaphragm	2.03 ± 0.26	1.87 ± 0.33	0.005**

(*) Independent T-test; (**) Mann whitney test

All diameters of thoracic aorta increased with hypertension with statistical significance (p <0.05), except at the level of the transverse aortic arch (P=0.051) as shown in Table 4.

DISCUSSION

In this study, the thoracic aortic diameters were evaluated in 140 Indonesian adults who had no obvious signs and symptoms of cardiovascular disease. The trend of overall thoracic aortic diameters is continuously decreased size from proximal to distal direction from aortic valve sinus to descending aorta at the level of diaphragm, which matches with Koju's study.[8]

Based on the results of this study as shown in Table 2, all diameters of thoracic aorta increased with age. The measurement of thoracic aortic diameter at each level had a significant difference with age ($p <0.001$). Increasing age is an independent and the most influential predictor of increasing size of thoracic aortic diameter in all aortic levels, which matches with the previous studies of Lee et al., which concluded that aortic dilatation is part of the natural aging process. The aorta is subject to constant pulsatile stress, so the elastic components of the aortic media fragment and eventually break down to be partially replaced by mostly fibrotic nonelastic tissue. These histological processes lead to stiffening of the aortic wall and increased mean aortic blood pressure, and finally to transverse dilation of the aorta.[1]

The study done by Hager et al. resulted that all diameters increased with age.[9] Musa also concluded that the diameters of thoracic aorta at different levels had significant relation with the age of the individual.10 Elastin fragmentation, fibrosis, and media necrosis occur in the aorta as signs of aging. Furthermore, various diseases alter aortic structure and may cause obstruction or dilatation of the aorta. Both obstruction and dilatation may be circumscript, segmental, or spread throughout the entire aorta.[9]

The analysis of the mean difference between thoracic aortic diameters and gender of the subjects based on the research that has been done shown in Table 3, the mean thoracic aortic diameters was significantly higher among males compared to females for all the measurement sites. Statistically, it was found that there was a significant difference in the mean of males research subjects compared to females ($p<0.001$). According to Prabhasavat's research, Men had slightly more enlarged aortic diameters in all eight predefined levels than women with statistical significance ($p<0.05$).[4] Similar results were also found in Lee's study in Korea. The study showed that Men had slightly larger thoracic aortic diameters than women ($p < 0.05$). We speculate that sex difference in the gross aortic diameter appeared to be associated with a difference in body size, as we all know that men have a larger body size than women.[1]

This study concluded All diameters of the thoracic aorta increased with hypertension as shown in Table 4. Statistically, it was found that there was a significant difference in the mean of subjects with history of hypertension compared to subjects with normotension ($p <0.05$), except at the level of the transverse aortic arch ($P=0.051$). These findings conform with the findings in the study done by Paul et al. who found hypertension ($p < 0.05$) were significantly associated with wider thoracic aortic diameters for all measured thoracic aortic diameters.[11] All thoracic aortic diameters increased with hypertension, with statistical significance ($p < 0.01$), which matches with a previous study by Lee et al. Blood pressure is well recognized for its effect on the thoracic aortic diameter. Previous studies have shown that hypertension has a significant bearing on the aortic diameter.[1]

Hypertension is traditionally regarded as a cause of aortic enlargement, even if this association is still under debate and controversial. According to the most widely accepted theory, aortic dilation observed in patients with hypertension may be the final result of an accelerated vascular aging pathway, in which the increased mechanical wall stress mediated by the increased blood pressure causes the fragmentation of elastin. On the basis of this hypothesis and given the high prevalence in patients with hypertension, aortic enlargement is considered hypertension-induced target organ damage.[12]

CONCLUSION

This study delineates normal thoracic aortic diameters for contrast-enhanced CT chest, including relationships with age, gender, and hypertension. The diameter of thoracic aorta decreased in the tapering fashion distally from the aortic valve sinus to descending aorta at the level of diaphragm. Age, male sex, and hypertension are associated with larger thoracic aortic diameters. The measurement of thoracic aortic diameter at each level had significant differences with age and gender ($p < 0.05$). All aortic diameters increased with hypertension ($p < 0.05$) except at the level of the transverse aortic arch (P=0.051).

DECLARATIONS

Ethics approval and consent to participate. Permission for this study was obtained from the Ethics Committee of Universitas Sumatera Utara and H. Adam Malik General Hospital.

CONSENT FOR PUBLICATION

The Authors agree to publication in Journal of Society Medicine.

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COMPETING INTERESTS

None.

AUTHORS' CONTRIBUTIONS

All authors significantly contribute to the work reported, whether in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas. Contribute to drafting, revising, or critically reviewing the article. Approved the final version to be published, agreed on the journal to be submitted, and agreed to be accountable for all aspects of the work.

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REFERENCE

1. Lee SH, Lee W, Choi HJ, Kim DJ, Park EA, Chung JW. et al. Measurement of the aortic diameter in the asymptomatic Korean population: Assessment with multidetector CT. Journal of the Korean Society of Radiology 2013, 69(2): 105-112. DOI: https://doi.org/10.3348/jksr.2013.69.2.105
2. Ehrman JK, Fernandez AB, Myers J, Oh P, Thompson PD, Keteyian SJ. Aortic Aneurysm: Diagnosis, Management, Exercise Testing, and Training. Journal of Cardiopulmonary Rehabilitation and Prevention 2020, 40(4): 215-223. DOI:10.1097/HCR.0000000000000521
3. Wang TKM, and Desai MY. Thoracic aortic aneurysm: Optimal surveillance and treatment. Cleveland Clinic Journal of Medicine 2020, 87(9): 557-568. DOI: 10.3949/ccjm.87a.19140-1
4. Prabhasavat K. Measurement of the Aortic Diameter in the Asymptomatic Thai Population in Siriraj Hospital: Assessment with Multidetector CT. Siriraj Medical Journal 2016, 68(4): 247-256.
5. Herring W. 2007. Learning radiology: Recognizing the basics. Elsevier Health Sciences.
6. Munden RF, Carter BW, Chiles C, MacMahon H, Black WC, Ko JP. et al. Managing incidental findings on thoracic CT: mediastinal and cardiovascular findings. A white paper of the ACR incidental findings committee. Journal of the American College of Radiology 2018, 15(8): 1087-1096. https://doi.org/10.1016/j.jacr.2018.04.029
7. Isselbacher EM. Thoracic and abdominal aortic aneurysms. Circulation 2005, 111(6): 816-828. https://doi.org/10.1161/01.CIR.0000154569.08857.7A
8. Koju A. and Joshi BR. Assessment of the Diameter of Thoracic Aorta by Computed Tomography of Chest. Nepalese Journal of Radiology 2018, 8(1): 13-19. https://doi.org/10.3126/njr.v8i1.20450
9. Hager A, Kaemmerer H, Rapp-Bernhardt U, Blücher S, Rapp K, Bernhardt TM. et al. Diameters of the thoracic aorta throughout life as measured with helical computed tomography. The Journal of thoracic and cardiovascular surgery 2002, 123(6): 1060-1066. https://doi.org/10.1067/mtc.2002.122310

10. Musa MGA. 2016. Measurement of Thoracic Aorta in Adult Sudanese Using Computed Tomography (Doctoral dissertation, Sudan University of Science and Technology).
11. Paul TK, Alamin AE, Subedi P, Alamian A, Wang L, Blackwell G. et al. Association Between Cardiovascular Risk Factors and the Diameter of the Thoracic Aorta in an Asymptomatic Population in the Central Appalachian Region. The American Journal of the Medical Sciences 2021, 361(2): 202-207. https://doi.org/10.1016/j.amjms.2020.07.034
12. Vizzardi E, Maffessanti F, Lorusso R, Sciatti E, Bonadei I, Gelsomino S. et al. Ascending aortic dimensions in hypertensive subjects: reference values for two-dimensional echocardiography. Journal of the American Society of Echocardiography 2016, 29(9): 827-837. https://doi.org/10.1016 /j.echo.2016.03.016