

Body-surface adjusted aortic reference diameters for improved identification of patients with thoracic aortic aneurysms: Results from the population-based Heinz Nixdorf Recall study

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ABSTRACT

Background: Early identification of patients at risk for thoracic aortic aneurysm (TAA) has the potential of improving prognosis. So far, however, “normal” aortic dimensions are not well defined, rendering identification of patients with enlarged aortas difficult. In the present study we aimed to (1) establish age- and gender-specific distribution of thoracic aortic diameters and (2) to determine the prevalence of asymptomatic TAA in a population-based European cohort.

Methods: Diameters of ascending thoracic aorta (ATA) and descending thoracic aorta (DTA) were measured from electron beam computed tomography (EBCT) scans of 4129 participants aged 45 to 75 years from the Heinz Nixdorf Recall study. Age- and gender-specific percentiles were calculated for body-surface adjusted aortic diameters. Multivariable linear regression was used to evaluate the association between aortic diameters and cardiovascular risk factors including age, gender and body-surface area (BSA).

Results: Aortic diameters were generally greater in the ATA than in the DTA, and were greater in men than in women (ATA: 3.71 ± 0.4 cm vs. 3.45 ± 0.4 cm, $p < 0.0001$; DTA: 2.82 ± 0.3 cm vs. 2.54 ± 0.3 cm, $p < 0.0001$). Age, male gender, blood pressure and body-surface area were independently associated with aortic diameters in both ATA and DTA. Based on our measurements age- and gender-specific percentiles for indexed ATA and DTA diameters were computed. Aneurysms ≥ 5 cm were found in 12 (0.34%) out of the total of 4129 subjects.

Conclusion: Since BSA was independently associated with increasing aortic diameters, correction of aortic diameters for BSA may be more helpful in order to reliably identify patients at risk for aneurysm formation. Based on the normal distribution of body-surface adjusted thoracic aortic diameters displayed in age- and gender-specific percentiles we suggest a cut-off point for aneurysmal aortic diameter at the 95th percentile.

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1. Introduction

Thoracic aortic aneurysm (TAA) is a serious condition, with the potential for severe complications such as aortic valve regurgitation and aortic rupture or dissection, frequently necessitating urgent open surgical or endovascular repair [1–4]. Generally, TAA is considered to be rare, but data on its prevalence are limited, both by sample size and

study population [5–7]. So far, only a single population-based study from Japan reported the prevalence of asymptomatic TAA with 0.16% (11 out of 6971 participants) [8]. Most recent data originate from Swedish national healthcare registers and have estimated the yearly incidence of TAA (>5 cm) including also aortic dissection to be 16.3 per 100,000 in men and 9.1 per 100,000 in women, respectively [9].

The prerequisite for estimating the prevalence of TAA is to determine specific cut-off values. The “normal” aortic dimensions are, however, still not well defined, although several studies have tried to establish reference values using transesophageal echocardiography, magnetic resonance imaging (MRI) or computed tomography (CT) [10–12], but are limited with respect to sample size and composition of analyzed patient cohorts. In clinical practice, an aortic diameter

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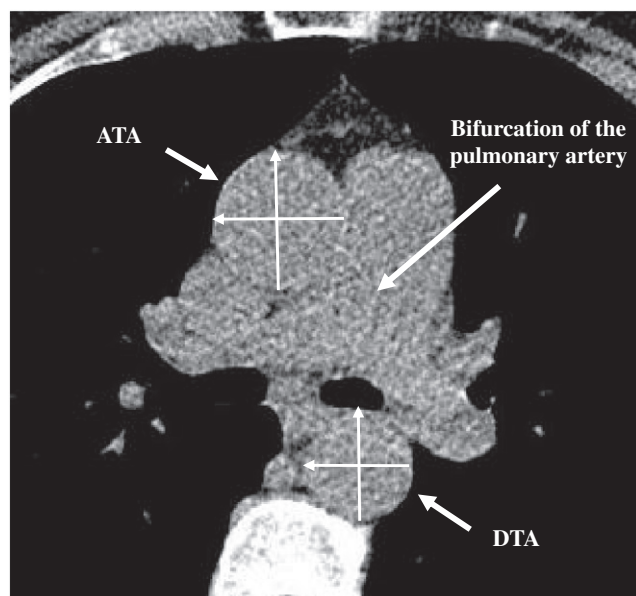


Fig. 1. Axial measurements of diameters of ascending thoracic aorta (ATA) and descending thoracic aorta (DTA) at the pulmonary artery bifurcation in non-contrast enhanced EBCT. Transaxial slice at the lower level of the pulmonary artery bifurcation from a computed tomography coronary artery calcium scan showing the method for deriving the ascending (ATA) and descending thoracic aortic diameter (DTA). The white arrows represent outer wall ATA and DTA diameter measurements perpendicular to the axis of rotation of the aorta.

exceeding 5 cm is usually considered an aneurysm requiring surgery. It would, however, be desirable to define aneurysm patients not only on a surgical retrospectively defined threshold [1,17].

It was the aim of the present study to (1) to establish age- and gender-specific percentile distribution of thoracic aortic diameters using the population-based cohort of the Heinz Nixdorf Recall study in Germany and (2) to calculate the prevalence of asymptomatic TAA.

2. Methods

2.1. Study population

The Heinz Nixdorf Recall study (Risk factors, Evaluation of Coronary Calcium and Lifestyle) is the first study in Europe, which assessed cardiovascular risk factors and the prevalence of signs of subclinical coronary atherosclerosis in an unselected cohort

representing the population of the Ruhr area with 6 million residents. Random samples of the general population were drawn from residents' registration offices of the German cities of Bochum, Essen, and Mülheim/Ruhr including men and women aged 45–74 years. We used a multimode contact approach including an invitational letter, a maximum of two reminder letters and phone calls for the recruitment of study subjects. Between December 2000 and August 2003, a total of 4814 subjects were included in this study. A further insight in the baseline recruitment manoeuvre has been described in detail elsewhere [18].

All participants gave informed consent, and the study protocol was approved by the institutional review board. Further details and additional references have been published previously [19].

2.2. Questionnaires and cardiovascular risk factors

A targeted assessment of medical history was performed and questionnaires with comprehensive risk-assessment were filled in with the help of a computerized assisted personal interview, including history of heart failure, a pacemaker or defibrillator but no known CAD, angina pectoris or cardiac catheterization without intervention, and history of stroke. Current regular use of medication including antihypertensive medication and lipid-lowering drugs was recorded by using a physician-based questionnaire [19–21]. Furthermore, a physical examination with assessment of anthropometric data such as height and body weight was performed. Blood pressure was measured with an automated oscillometric blood pressure device (Omron 705-CP, OMRON, Germany) and was recorded three times for each participant (with a 3-minute interval in between). Measurements of blood pressure were performed during the computerized assisted personal interview that was automatically interrupted for the blood pressure recording, depending on the length of a subject's occupational history. This course of action guaranteed that subjects rested at least 5 min before their first blood pressure measurement. Study personnel were certified and regularly trained in measuring blood pressure according to the standards of the World Health Organization (WHO) MONICA blood pressure recording protocol [22]. Blood pressure was classified according to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-VII) threshold values [23]. Accordingly, arterial hypertension was defined as a value $\geq 140/90$ mm Hg and/or an antihypertensive medication.

Body mass index (BMI [kg/m^2]) was calculated from standardized measurements of height and weight. Body-surface area (BSA) was calculated employing the Mosteller formula, which includes participant's height and weight [24]. Current smoking was defined as a history of cigarette smoking during the past year. Standard enzymatic methods were used to measure total cholesterol and other risk factors. Participants were considered diabetic if they reported a physician diagnosis of diabetes or were taking anti-diabetic medication.

2.3. Electron beam computed tomography (EBCT)

Participants received a non-contrast enhanced EBCT to quantify the amount of subclinical coronary artery calcification (CAC). The methodology for acquisition and interpretation of the scans has been reported previously [25–27]. The EBCT studies were performed by an Imatron (South San Francisco, California) C-150 XL ultrafast computed tomographic scanner in the high-resolution volume mode using a 100-ms exposure time. Electrocardiographic triggering was used so that each image was obtained at the same point in diastole, corresponding to 80% of the RR-interval for standardized calcium scoring. Forty consecutive images were obtained at 3-mm

Table 1a

Baseline characteristics of male participants in relation to age.

	Age						
	all (n = 1959)	45–49 (n = 261)	50–54 (n = 370)	55–59 (n = 347)	60–64 (n = 441)	65–69 (n = 326)	+ 70 (n = 214)
Weight (kg)	86.2 ± 13	87.4 ± 14.1	86.1 ± 12.7	85.9 ± 13.3	86.7 ± 12.5	86.1 ± 13.0	84.6 ± 12.9
Height (cm)	175.1 ± 6.8	177.2 ± 6.9	176.5 ± 6.3	175.6 ± 6.3	175.2 ± 6.7	173.4 ± 6.4	171.3 ± 7.0
Body mass index (kg/m^2)	28.1 ± 3.9	27.8 ± 3.9	27.6 ± 3.6	27.8 ± 3.9	28.2 ± 3.7	28.6 ± 4.1	28.9 ± 4.2
Body-surface area (m^2)	2.04 ± 0.17	2.07 ± 0.19	2.05 ± 0.17	2.04 ± 0.17	2.05 ± 0.17	2.03 ± 0.17	2.0 ± 0.17
Systolic BP (mmHg)	138.2 ± 19.3	130 ± 17.1	132.7 ± 17.3	136.3 ± 17.4	140.1 ± 18.7	144.2 ± 20.1	147.4 ± 20.6
Diastolic BP (mmHg)	84.4 ± 10.4	83.7 ± 10.8	84.9 ± 10.7	85.0 ± 9.9	84.6 ± 9.3	84.6 ± 9.3	82.4 ± 10.2
Prevalence of hypertension							
JNC-7 stage 1	620 (31.7)	58 (22.2)	90 (24.4)	114 (32.9)	153 (34.7)	119 (36.6)	86 (40.6)
JNC-7 stage 2	259 (15.1)	23 (8.8)	41 (11.1)	40 (11.5)	70 (15.9)	71 (21.9)	50 (23.6)
Antihypertensive drugs n (%)	606 (30.9)	38 (14.6)	84 (22.7)	95 (27.4)	142 (32.2)	141 (43.3)	106 (49.5)
Diabetes n (%)	170 (8.7)	10 (0.5)	24 (1.2)	35 (1.8)	39 (2.0)	30 (1.6)	32 (1.6)
Hypercholesterol. n (%)	977 (50.9)	124 (6.5)	168 (8.8)	193 (10.0)	228 (11.9)	160 (8.3)	104 (5.4)
Lipid-lowering drugs n (%)	158 (8.1)	10 (3.8)	19 (5.1)	37 (10.7)	42 (9.5)	30 (9.2)	20 (9.4)
Current smoker n (%)	495 (25.3)	94 (4.7)	131 (6.7)	95 (4.9)	88 (4.5)	46 (2.4)	41 (2.1)
Former smoker n (%)	882 (45.1)	92 (4.7)	139 (7.1)	150 (7.7)	216 (11.1)	161 (8.2)	124 (6.3)
Never smoker n (%)	579 (29.6)	74 (3.8)	99 (5.1)	102 (5.2)	137 (7.0)	118 (6.0)	49 (2.5)
CAC median (Q1–Q3) (Agatston-Score)	55.7 (4.4–242.1)	4.8 (0.0–60.1)	12.4 (0.0–78.6)	51.6 (6.7–196.7)	86.7 (11.9–320.5)	127.7 (24.2–414.9)	199.2 (51.3–747.5)

Values are mean ± SD or count (%), unless otherwise specified. Abbreviations: BP = blood pressure, CAC = coronary artery calcification, Q1–Q3 = 1–3. Quartile, Hypercholesterol. = hypercholesterolemia. JNC-7 = Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.

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