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Original Research Article

Assessment of the thoracic aorta by multidetector computed tomography: Age- and sex-specific reference values in adults without evident cardiovascular disease

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KEYWORDS:
Aortic root;
Computed tomography;
Normal;
Thoracic aorta

BACKGROUND: Dilatation of the aortic root and other segments of the thoracic aorta is important in the pathogenesis of aortic regurgitation and of aortic dissection. Although echocardiographic criteria exist to detect aortic root dilation, comparably standardized methods have not been developed to detect enlargement of the remainder of the thoracic aorta. Nongated axial chest computed tomography (CT), traditionally used to evaluate aortic size, does not account for the obliquity, systolic expansion, and nonaxial motion of the aorta during the cardiac cycle. Reference values for aortic diameters in anatomically correct double-oblique short axis images have not been established with the use of electrocardiogram (ECG)-gated 64-detector row multidetector CT (MDCT).

OBJECTIVES: To establish reference values for thoracic aortic diameters MDCT in healthy normotensive nonobese adults without evident cardiovascular disease.

METHODS: A total of 103 (43% women, age 51 ± 14 years) consecutive normotensive, nonobese adults free of cardiac or aortic structural disease or arrhythmia underwent MDCT examination to determine aortic dimensions.

RESULTS: End-diastolic diameter 95% confidence intervals were 2.5–3.7 cm for the aortic root, 2.1–3.5 cm for the ascending aorta, and 1.7–2.6 cm for the descending thoracic aorta. Aortic diameters were significantly greater at end systole than end diastole (mean difference 1.9 ± 1.2 mm for ascending and 1.3 ± 1.8 for descending thoracic aorta, $P < 0.001$). Aortic root and ascending aortic diameter increased significantly with age and body surface area.

CONCLUSIONS: This study establishes age- and sex-specific ECG-gated MDCT reference values for thoracic aortic diameters in healthy, normotensive, nonobese adults to identify aortic pathology by MDCT. MDCT measurements of the thoracic aorta should use ECG-gated double-oblique short-axis images for accurate quantification.

Conflict of interest: The authors report no conflicts of interest.

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Introduction

Dilatation of the aortic root and thoracic aorta predisposes patients to aortic regurgitation and aortic dissection.[1] Normal limits for aortic root diameter in relation to age and body size have been developed and widely adopted, but only limited data exist concerning reference values for diameters of more distal aortic segments.[2,3] Advances in multidetector computed tomographic (MDCT) scanners provide high spatial, temporal, and contrast resolution which, when coupled with electrocardiographic (ECG)-gating, permit true 3-dimensional (3D) assessment of cardiovascular (CV) structure and function.[4] Historically, nongated axial chest CT has been used to evaluate thoracic aortic size for prognosis and management. However, aortic imaging by nongated axial chest CT cannot account for the obliquity of structures or for systolic expansion and nonaxial motion during the cardiac cycle. ECG-gated 64-detector row scanners permit 3D reorientation and measurement of the thoracic aorta in true double-oblique short axes, rather than axial views, at specific points during the cardiac cycle.

To date, reference values for ECG-gated double-oblique short axis measures of thoracic aortic anatomy have not been established for MDCT. "Normal" values for MDCT cannot be derived from reference values for echocardiography or cardiac magnetic resonance imaging (CMR) because of intrinsic differences in image acquisition, temporal and spatial resolution, and signal-to-noise levels. The use of axial CT standards not based upon a vessel's true short axis or use of extrapolated standards from CMR or echocardiography in MDCT may misclassify patients for prognosis and management.

In this study, we define a technique for measuring diameters of the thoracic aorta using 64-detector row ECG-gated MDCT in a healthy, normotensive nonobese population free of cardiovascular (CV) and aortic disease by history and MDCT. Furthermore, we determined age- and gender-specific reference values appropriate for body size.

Methods

Population

The study population consisted of consecutive subjects ≥18 years of age who underwent clinically indicated, 64-detector row cardiac MDCT angiography at the New York Presbyterian Hospital or Tennessee Heart and Vascular Institute from 2005 to 2007. Nurses interviewed subjects prospectively for CV disease, risk factors, and symptoms. MDCT data were evaluated after completion of the scan. Subjects were excluded if they had significant CV or aortic diseases, hypertension, or obesity by history or MDCT findings. CV diseases were defined as arrhythmic or conduction disease, valvular stenosis or significant regurgitation, infarct or obstructive coronary artery disease, Agatston score >400, cardiomyopathy, or congenital heart disease. Aortic disease was defined as aortic dilation diagnosed by another modality (such as echocardiography or computed magnetic resonance angiography), dissection, hematoma, aneurysm, or complex atheroma (≥0.4 cm). Hypertension was defined by a previous diagnosis of hypertension or previous treatment with medications, as study blood pressures were all measured while receiving beta blockade. Body mass index was calculated and used to categorize patients as normal weight (<25), overweight (≥25 and <30), and obese (≥30). This study was approved by the Institutional Review Boards of the Cornell Medical College and the Tennessee Heart and Vascular Institute.

Cardiac MDCT angiography

Subjects underwent cardiac MDCT by a standard protocol, as previously described.[5] Subjects received metoprolol to a goal heart rate <65 beats/min and 0.4 mg of sublingual nitroglycerin before undergoing MDCT. All MDCT scans at both sites were performed with a 64-detector row CT scanner (Lightspeed VCT, GE Healthcare, Milwaukee, WI) with the inclusion of a triple-phase contrast protocol: 60 mL of iodixanol, followed by a 50 mL of a 50:50 mixture of iodixanol and saline, followed by a 50-mL saline flush. MDCT field of view was from the aortic arch to inferior to the cardiac apex. The scan parameters were 64 $\times$ 0.625-mm collimation, tube voltage 120 mV, mA 350–750. Upon MDCT completion, 20 phases of axial data at 2.5-mm slice thickness were reconstructed from beginning to the end of the cardiac cycle at 5% increments.

Aortic measurements

Multiphasic reconstruction, postprocessing, and image interpretation were performed by 2 interpreting physicians blinded to clinical history. All images were examined on an AW 4.3 Advantage Workstation (GE Healthcare, Milwaukee, WI). Aortic double-oblique short axes (D-SAX) were determined with a 3D workstation program with the long axis oriented from the mid-vessel on the sagittal plane and the short axis oriented perpendicular to the vessel wall on the oblique plane. Aortic D-SAX views were reoriented separately for each vessel at end diastole (ED) and end systole (ES) for measurement. Aortic measurements were indexed to body surface area (BSA), as previously established for echocardiography.

Linear measurements. Intraluminal measurements were made from the iodinated contrast-tissue border interface for a measure of the true cavity without inclusion of the aortic tissue. Short-axis aortic root measurements were made at the sinuses of Valsalva in ED (Fig. 1A). Measurements were made from each coronary sinus to its opposite trigone. D-SAX anteroposterior (AP) and lateral ED diameters of the ascending and descending thoracic aorta were measured at the level of the main pulmonary artery bifurcation (Fig. 1, B and C). Ascending and descending thoracic aortic mea-