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Original article

Aortic dimensions by multi-detector computed tomography vs. echocardiography

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ABSTRACT

Objective: Clinical follow-up of aortic dimensions is performed interchangeably by multi-detector computed tomography (MDCT) and by cardiac echocardiography (ECHO). This study assesses the relationship between measurements of the aortic diameter by MDCT and ECHO at various predetermined locations using several methods.
Methods: The aortic diameter was measured at 6 locations between the aortic annulus and the aortic arch in 49 patients who underwent both MDCT and ECHO. Measurements were performed by three methods: internal-to-internal edge (INT), external-to-internal edge (MIX), and external-to-external edge (EXT). Measurements by MDCT and ECHO were made by an experienced radiologist and cardiologist, respectively, both blinded to results and images from the other modality.
Results: The average aortic diameter at all locations was significantly different between the MDCT and ECHO by all three methods (INT: 30.0 ± 5.8 mm vs. 27.8 ± 5.9 mm; MIX: 31.5 ± 5.8 mm vs. 30.8 ± 5.8 mm; EXT: 32.9 ± 6.6 mm vs. 33.8 ± 6.5 mm, $p < 0.002$ for all). While mean absolute differences between INT and EXT methods were similar (3.5 ± 3.1 mm and 3.4 ± 2.7 mm, respectively), the absolute difference using the MIX method was significantly smaller (3.1 ± 2.8 mm; $p < 0.001$ for INT vs. MIX; $p < 0.05$ for EXT vs. MIX).
Conclusions: There is considerable variability between MDCT and ECHO measurements of the ascending aorta. Measuring the aortic diameter by the MIX provides the closest measurements and is advised for long-term follow-up.

Introduction

Repeated imaging in patients with aortic dilatation is necessary for determining the rate of progression of dilatation and ultimately, for determining the optimal timing of repair. Noninvasive aortic measurements can be obtained by multi-detector computed tomography (MDCT), magnetic resonance imaging (MRI), and trans-thoracic echocardiography (ECHO), all of which are well-established imaging modalities used for aortic measurement [1]. Each modality has its limitations: CT involves exposure to ionizing radiation and intravenous contrast agent injection, MRI is expensive and not easily accessible in most locations in the world, and visualization of the aorta by echocardiography is often limited and highly dependent on technician acuity.

In the interest of minimizing ionizing radiation, following an initial MDCT study of the aorta (considered the gold standard), ECHO is commonly used for monitoring aortic dilatation during follow-up, with MDCT studies performed periodically or when further aortic dilation is suspected. However, to the best of our knowledge, no study to date has determined what measurement method by each modality should be used for comparison between them, at which locations along the aorta are both modalities most concordant and what is the range of measured diameter differences between modalities utilizing the same measurement method. Our aim was twofold: A. to compare MDCT and ECHO measurements of the aortic diameter and thus to provide data on which to base recommendations for echocardiographers and radiologists as to how and where to perform concordant aortic

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measurements and B. to facilitate interpretation of differences between measurements obtained by both modalities when using various measurement methods.

Materials and methods

Forty-nine consecutive adult patients without known thoracic aortic dilatation were included in the study. All patients underwent both contrast-enhanced chest MDCT and ECHO studies for clinical indications. All ECHOs were performed within 48 h of MDCT.

Three measurement techniques were employed with each modality to determine the aortic diameter at each level: internal-to-internal edge (INT), external-to-internal edge (MIX, also known as "leading-edge-to-leading-edge"), and external-to-external edge (EXT) (Fig. 1).

Measurements were performed at the following six levels: (1) the aortic annulus (ANN) at the hinge points of the aortic cusps; (2) the sinuses of Valsalva (SIN); (3) the sino-tubular junction (STJ); (4) the proximal ascending aorta, 2–3 cm above the sino-tubular junction (PROX); (5) the widest point of the ascending aorta (MAX); and (6) at the aortic arch (ARCH) (Figs. 2 and 3).

MDCT was performed using a 64-row scanner (Brilliance 64, Philips Medical Systems, Cleveland, OH, USA). During each scan, 60 ml of contrast agent (Iomeron 350 mg/ml, Bracco, Milan, Italy) was injected intravenously at a rate of 2 ml/s, followed by a saline chaser bolus (bolus tracking). For MDCT conventional contrast-enhanced chest CT was used, rather than electrocardiogram-gated cardiac CT. The analysis of the aorta was performed on a dedicated Philips EBW (Extended Brilliance Workspace; Philips, Amsterdam, the Netherlands) workstation (version 3.5) with post-processing done on the Advanced Vessel Analysis module. As in previous studies [2,3], cross-sectional MDCT images of the aortic annulus, sinuses of Valsalva, sino-tubular junction, ascending aorta, and aortic arch perpendicular to the centerline were created. One faculty radiologist with 10 years of experience evaluated the CT studies. The MDCT measurements were obtained manually on cross-sectional MDCT images at each location in areas of minimal calcification to avoid partial volume averaging artifacts (Fig. 2).

Full standard ECHO studies were performed on each patient with commercially available machines (Vivid I, 6 or 7, GE Healthcare, Little Chalfont, UK). Aortic dimensions at each of the above locations using each of the above measurement methods

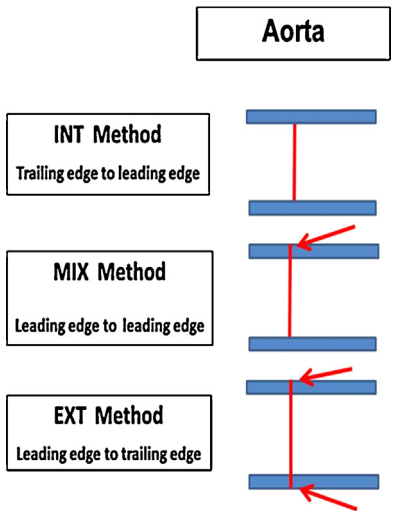

Fig. 1. A schematic representation of three measurement methods used to determine aortic diameter at each measurement site. INT = minimal aortic diameter, measured from trailing edge to leading edge, representing net aortic lumen diameter. MIX = intermediate aortic diameter measured from leading to leading edge, represents diameter of net lumen and anterior wall. EXT = maximal aortic diameter, measured from leading to trailing edge, represents diameter of net lumen and both walls.

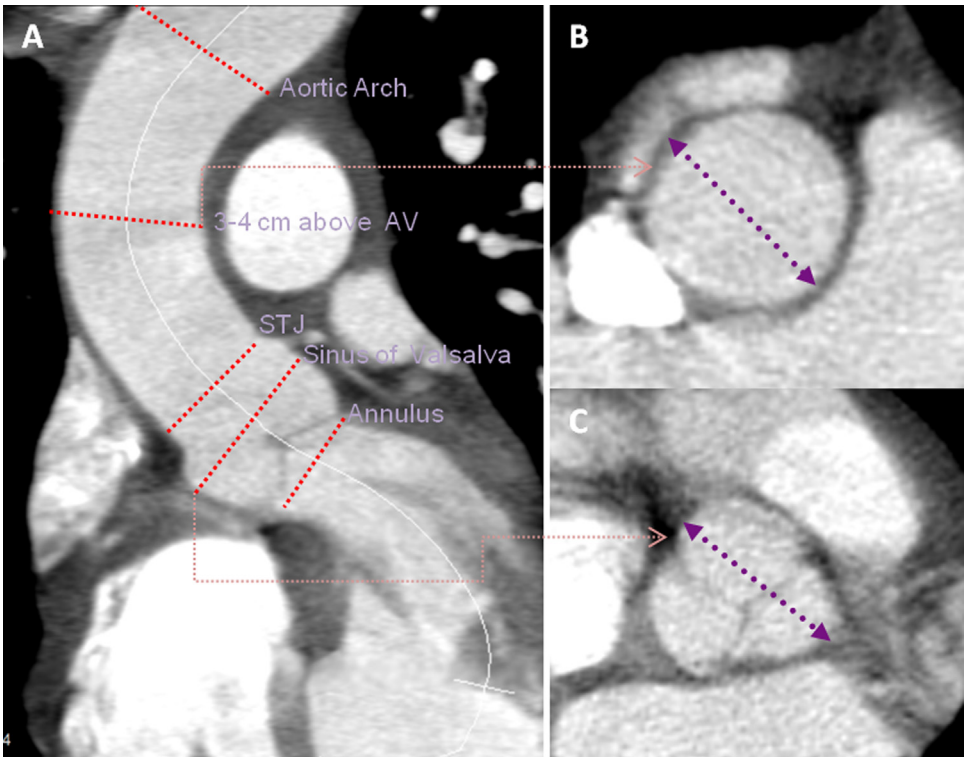

Fig. 2. Example of measurement of the aortic dimensions at different locations. (A) Oblique sagittal contrast-enhanced reformatted multi-detector computed tomography (MDCT) image shows aortic dimensions measurements (dashed lines) at various levels: aortic annulus, sinus of Valsalva, sinotubular junction (STJ), 3–4 cm above aortic valve (AV), and aortic arch. Cross-sectional MDCT images of the aorta at various levels (perpendicular to the centerline) were created. Measurements in cross-sectional images at the sinus of Valsalva (B) and ascending aorta (C) are demonstrated.