Comparison of Feasibility and Accuracy of Transthoracic Echocardiography Versus Computed Tomography in Patients With Known Ascending Aortic Aneurysm

Gloria Tamborini, MD*, Claudia Agnese Galli, MD, Anna Maltagliati, MD, Daniele Andreini, MD, Gianluca Pontone, MD, Carlo Quaglia, MD, Giovanni Ballerini, MD, and Mauro Pepi, MD

Aortic valve diseases, hypertension, and connective tissue disorders may be causes of ascending aortic aneurysms. Aortic enlargement monitoring is essential for surgical timing and for operative design. In this regard, several imaging techniques may have limitations: magnetic resonance is not widespread and is expensive, computed tomography uses radiation, and transesophageal echocardiography is a semi-invasive method. The aim of this study was to analyze the feasibility of transthoracic echocardiography in the evaluation of aortic dimensions and its accuracy in comparison with multidetector computed tomography. In 44 patients with known ascending aortic aneurysms, transthoracic echocardiographic and computed tomographic measurements were obtained and compared at different levels: the annulus, sinuses of Valsalva, sinotubular junction, ascending aorta, and aortic arch. Transthoracic echocardiographic diameters were obtained in all patients, apart from the aortic arch, which was measured in 40 cases. Transthoracic echocardiographic and computed tomographic diameters correlated significantly ($p < 0.001$), with very small SEEs: for the annulus, $r = 0.846$ (SEE 0.37); for the sinuses of Valsalva, $r = 0.967$ (SEE 0.35); for the sinotubular junction, $r = 0.965$ (SEE 0.33); for the ascending aorta, $r = 0.976$ (SEE 0.41); and for the aortic arch, $r = 0.87$ (SEE 0.50). In conclusion, transthoracic echocardiography is a feasible and accurate technique for the assessment and follow-up of thoracic aortic diameters in patients with ascending aortic aneurysms. **(Am J Cardiol 2006;98:966–969)**

Transesophageal echocardiography, magnetic resonance imaging (MRI), and contrast-enhanced computed tomography are known to be accurate methods for the evaluation of ascending aortic diseases.[1–6] Transesophageal echocardiography is a semi-invasive technique, computed tomographic (CT) scans use x-rays and contrast-agent injections, and MRI is a less accessible and more expensive method. For these reasons, none of these 3 techniques is the ideal method for monitoring aortic dimensions. Transthoracic echocardiography may be used if image quality is adequate, and recent advances, including the introduction of the second harmonic technique and high-resolution probes, have improved the transthoracic echocardiographic (TTE) visualization and measurement of the ascending aorta in most patients. No studies have prospectively compared transthoracic echocardiography with computed tomography (considered the gold standard) for the assessment of the aorta (including all the main measurements of the aortic root, ascending aorta, and aortic arch). The aim of the present study was to compare TTE and CT scans in the evaluation of ascending aortic dimensions in patients with known aortic dilation.

Methods and Results

Forty-four patients with known ascending aortic dilation or aortic aneurysms were included in the study. The aorta was considered dilated if its diameters exceeded the norms for age and body size and aneurysmatic when the dilation was >50% more the normal diameter.[7,8] The dilation of the ascending aorta in our patients was due to atherosclerotic disease in 21 patients, Marfan's syndrome or familial history of thoracic aortic aneurysm or dissection in 13 patients, or bicuspid aortic valves in 10 patients. Complete TTE studies were performed in all patients using a Sonos 7500 ultrasound unit and an S3 probe (Philips Medical Systems, Andover, Massachusetts). Two-dimensional echocardiography included all standard views, and aortic dimensions were obtained from parasternal or suprasternal windows. The ascending aorta was measured in the parasternal view at 4 levels (Figure 1): (1) the aortic annulus at the hinge points of the aortic cusps, (2) the sinuses of Valsalva, (3) the sinotubular junction, and (4) the ascending aorta at the point of maximal measurable dimension beyond the sinotubular junction. The aortic arch was measured from the suprasternal window between the innominate and left carotid artery. Each TTE measurement was performed at end-diastole, perpendicular to the aortic long axis and according to leading-edge technique in views showing the largest aortic diameter. Within 24 hours of transthoracic echocardiography, multidetector computed tomography was performed with electrocardiographic gating,

Centro Cardiologico Monzino, I.R.C.C.S, Institute of Cardiology, University of Milan, Milan, Italy. Manuscript received January 16, 2006; revised manuscript received and accepted April 25, 2006.

*Corresponding author: Tel: 0039-2-580021; fax: 0039-2-504667.
E-mail address: gtamborini@cardiologicomonzino.it (G. Tamborini).

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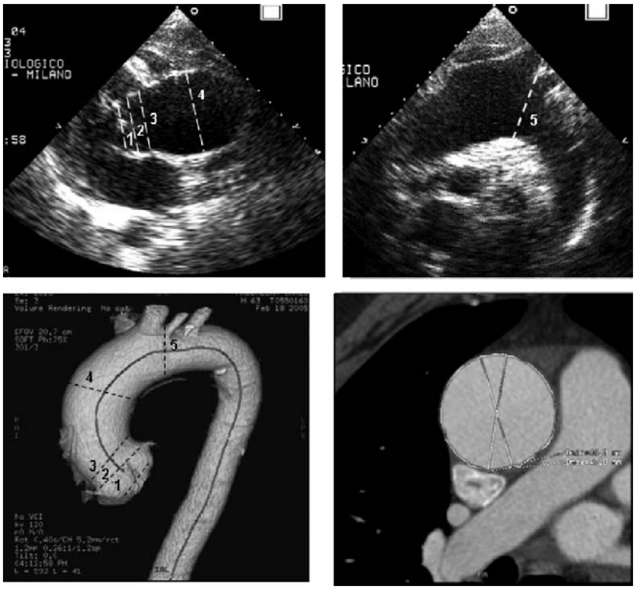

Figure 1. Example of measurement of the aortic dimensions. *Upper panels*, echocardiographic measurements *(dashed lines)* in parasternal *(A)* and suprasternal *(B)* views: 1 = aortic annulus, 2 = sinuses of Valsalva, 3 = sinotubular junction, 4 = ascending aorta, 5 = aortic arch. *Lower panels*, CT reconstructions of the aorta. CT measurements were obtained at the same echocardiographic levels *(C)*; in each transverse section of the aorta (perpendicular to the long axis) the maximal diameter was considered *(D)*.

Table 1
Demographic and echocardiographic data of the study population

Variable	Total (n = 44)	Atherosclerotic Aneurysm (n = 21)	Marfan's Syndrome (n = 13)	Bicuspid Valve (n = 10)
Age (yrs)	59 ± 15	70.5 ± 5	48.5 ± 13†	49.1 ± 12†
Women/men	15/29	9/12	4/9	2/8
Body surface area	1.8 ± 0.2	1.7 ± 0.2	1.9 ± 0.2*	1.8 ± 0.1
Annulus	22.3 ± 2	20.9 ± 2	25.5 ± 3†	22.1 ± 2‡
Sinuses of Valsalva	44.8 ± 9	44.6 ± 7	46.7 ± 13	42.6 ± 5
Sino tubular junction	43.6 ± 8	44.3 ± 7	43.5 ± 12	42.1 ± 6
Ascending aorta	52.4 ± 12	52.1 ± 10	48.7 ± 12	57.7 ± 13
Aortic arch	37.9 ± 7	38.8 ± 7	37.2 ± 7	37.2 ± 6

* $p < 0.05$.

† $p < 0.01$: significance of the difference between patients with Marfan's syndrome or bicuspid valves and atherosclerotic patients.

‡ $p < 0.05$: significance of the difference between patients with bicuspid valves and Marfan's syndrome.

using a 16-row scanner (Light Speed Pro, GE Medical Systems, Waukesha, Wisconsin). During the scan, 110 ml of contrast agent (Iomeron 400 mg/ml, Bracco, Milan, Italy) was injected intravenously at a rate of 3.5 ml/s using the bolus-tracking technique. The CT data sets were analyzed using a dedicated software package for vessel analysis (CardioQ3, GE Medical Systems). The CT measurements of the aorta were obtained at the same echocardiographic levels in the transverse section from the 3-dimensional reconstruction of aorta, and the largest diameter in each section was then considered (Figure 1).

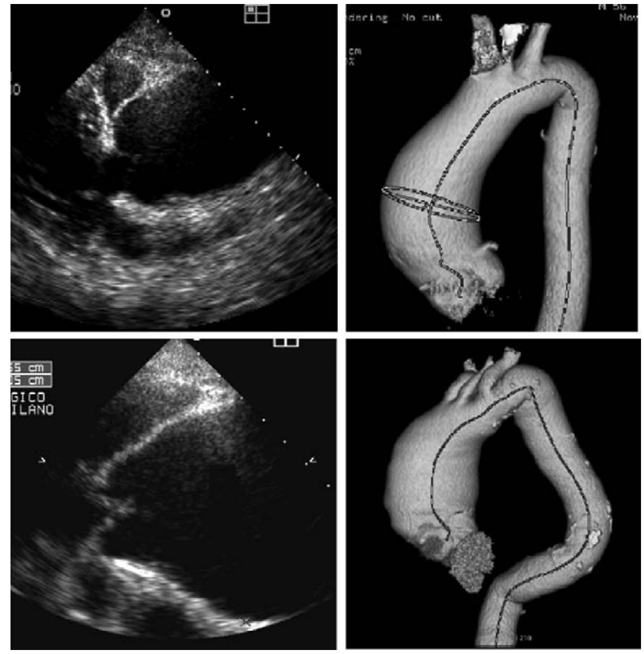

Figure 2. Examples of aortic aneurysms in a patient aged 47 years with Marfan's syndrome involving the sinuses of Valsalva and the ascending aorta *(upper panels)* and in a hypertensive patient aged 89 years *(lower panels)* in whom aortic dilation spared the aortic root (35 mm) and showed marked aneurysm of the ascending aorta (70 mm).

Table 2
Correlations between echocardiographic and computed tomographic measurements

Variable	TTE Measurements	CT Measurements	Pearson's Correlation	p Value
Annulus	22.8 ± 3	23.2 ± 3	0.846	0.000
Sinuses of Valsalva	43.4 ± 9	44.8 ± 9	0.967	0.000
Sino tubular junction	42.4 ± 8	43.6 ± 8	0.965	0.000
Ascending aorta	52.5 ± 12	53.2 ± 12	0.976	0.000
Aortic arch	35.3 ± 6	37.9 ± 6	0.870	0.000

All TTE and CT images were analyzed by 4 experts in transthoracic echocardiography and cardiac computed tomography. Two investigators (MP and GT) reviewed the TTE images independently and without knowledge of the CT findings. Two experts in CT (GP and DA) reviewed the CT images blinded to the echocardiographic results. TTE and CT measurements at the same level were compared.

Data are expressed as mean ± SD. The paired Student's *t* test was used to compare TTE and CT measurements and the Bland-Altman test to assess the bias (systematic error) between the 2 techniques. Correlations between TTE and CT differences and aortic dimensions at each level were obtained by Pearson's test. TTE and CT measurements were repeated by a second independent observer in 15 patients to assess interobserver variability, and the first observer measured these 15 data sets on a different day to assess intraobserver variability. Observer variability was then calculated

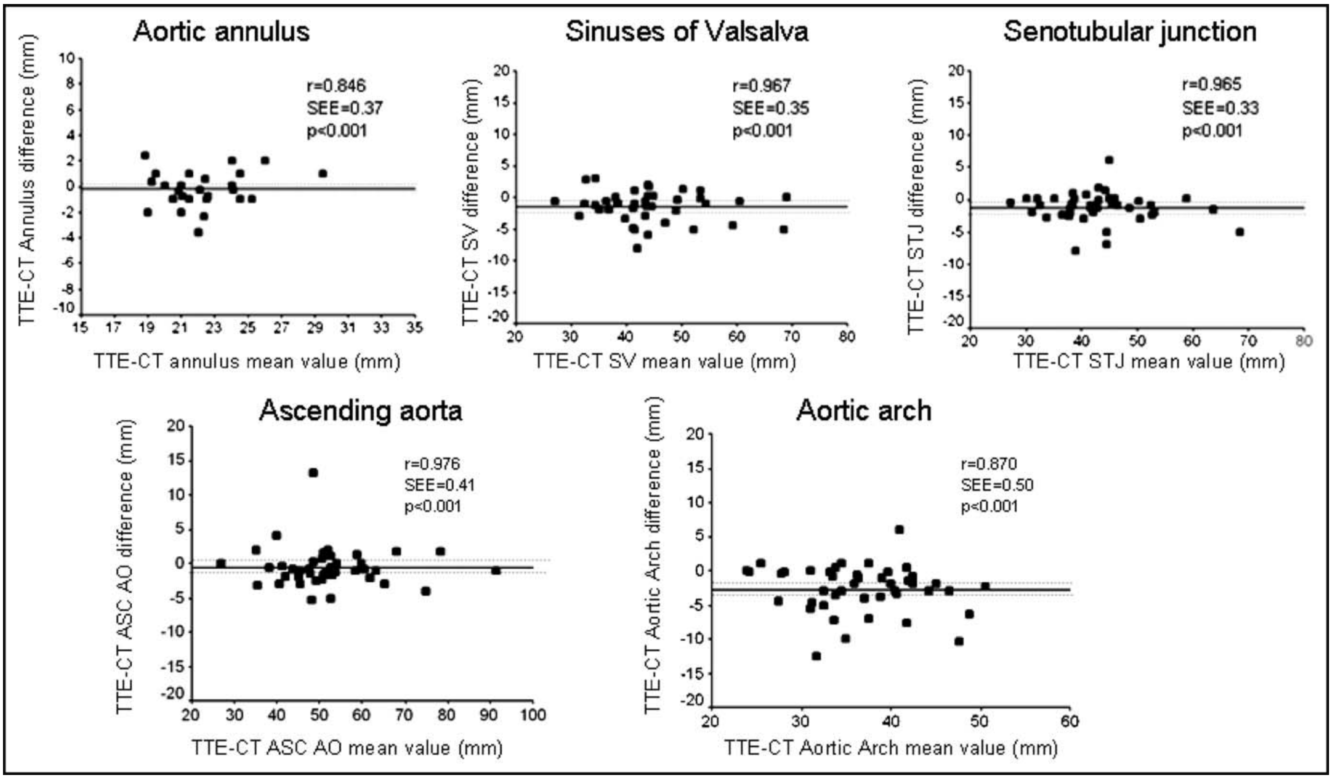

Figure 3. Bland-Altman plots of the difference in aortic diameter between TTE and CT measurements as a function of the average measurements. *Thick continuous and dotted lines,* mean ± 2 SDs of the difference, respectively. ASC = ascending; STJ = sinotubular junction; SV = sinuses of Valsalva.

as the SD of the differences of the 2 measurements and is expressed as a percentage of the mean value.

Demographic and echocardiographic data of the patients are listed in Table 1. Patients with atherosclerotic disease were significantly older in comparison with the other groups, whereas patients with Marfan's syndrome or familial aortic disease had larger body surface areas and aortic annuli (Figure 2). TTE measurements (aortic annulus, sinuses of Valsalva, sinotubular junction, and ascending aorta) were performed from the parasternal window in all patients. Aortic arches were measured in 40 patients (91%), whereas in 4 patients, accurate evaluations of aortic arch dimensions were not possible because of poor acoustic suprasternal windows. TTE and CT measurements of the ascending aorta were strictly correlated (Table 2), without significant differences and with very small SEEs between the values (Figure 3). Differences between CT and TTE data were not correlated with the dimensions of the aorta at all levels of the vessel, with the exception of the aortic arch ($r = -0.5$, $p < 0.001$). Inter- and intraobserver variabilities of the TTE measurements were 2.7 mm (6%) and 1.3 mm (3%), respectively. Inter- and intraobserver variabilities of the CT measurements were 1.9 mm (4%) and 1.7 mm (3.6%), respectively.

Discussion

This prospective study comparing transthoracic echocardiography and computed tomography shows that transthoracic echocardiography is an accurate and reproducible method for evaluating the aortic root, the proximal ascending aorta, and the aortic arch. Prophylactic surgical resection on a dilated ascending aorta when a certain "size threshold" is reached is recommended to prevent the morbidity and mortality associated with aortic dissection or rupture.[9,10] In asymptomatic patients, surgery is generally recommended when the aortic diameter reaches 5 or 5.5 cm. In patients with Marfan's syndrome or familial thoracic aortic aneurysm or dissection or in patients with bicuspid aortic valves, surgery is recommended at ≤5 cm.[11–16] Therefore, serial follow-up evaluation of patients with dilated aortic roots should be performed every 6 to 12 months, depending on the size of the aorta, clinical status, and co-existing valve pathologies.[1,17,18] Moreover, aortic root dilation is an important cause of aortic regurgitation, and idiopathic aortic root dilation may be the most common cause of aortic regurgitation in industrialized countries.[7,17] In these cases, the morphology of the aortic valve and measurements of the aorta at the level of the annulus, sinuses of Valsalva, sinotubular junction, and ascending aorta are crucial to define indications and surgical planning. These anatomic findings usually dictate whether the valve can be spared or other surgical techniques may be indicated.[16,19]

This is the first study comparing all these TTE measurements with multidetector computed tomography (considered the gold standard). A main finding of this study is the demonstration that TTE measurements of all aortic segments are feasible, providing accurate anatomic calculations. We showed that from the parasternal view, in a series of patients with known aortic dilatation or aneurysms, main TTE measurements of the proximal and ascending aorta were highly correlated with CT measurements, with very small SEEs and relatively low inter- and intraobserver variabilities. Data concerning the aortic arch obtained from the suprasternal window were also highly correlated with CT measurements, although with greater SEEs and greater inter- and intraobserver variabilities. We selected a population with dilation of the aorta related to different causes. Despite typical differences in morphologies in patients with Marfan's syndrome (pear-shaped aortic roots), bicuspid aortic valves (involving the sinuses of Valsalva and th sinotubular junction), or atherosclerosis (fusiform or saccular dilation), our data clearly show that echocardiography is accurate independently for the different pathologies. Computed tomography is an effective method for defining the entire thoracic aorta and the maximum diameter of the aneurysmatic portion and monitoring the diameter over time. However, computed tomography uses x-rays and contrast agents and does not provide anatomic and functional information on the aortic valve and heart dimensions and function. Alternatively, MRI could be used as a very accurate technique in this field, but it is less accessible and more expensive. Transesophageal echocardiography provides a substantially broader window to aortic anatomy and pathology than transthoracic echocardiography, but it is a semi-invasive technique, and it is mainly indicated in acute aortic syndromes.[1,2,9] Our data suggest echocardiography as an ideal method for monitoring aortic root and ascending aortic size, whereas more expensive techniques (computed tomography and MRI) may be used selectively and appropriately during the follow-up of patients with aortic aneurysms, particularly when surgery or a complete definition of the entire aorta and aortic branches is indicated.

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