# Normal Values and Differences in Ascending Aortic Diameter in a Healthy Population of Adults as Measured by the Pediatric versus Adult American Society of Echocardiography Guidelines

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*Background:* There is a lack of uniformity across echocardiographic society guidelines as to how the diameter of the ascending aorta is to be measured. The aims of this study were to compare measurements done using the diastolic leading edge–to–leading edge and systolic inner edge–to–inner edge (SIE) techniques in a large cohort of healthy adult individuals and to report the normal values for adults using the SIE technique.

*Methods:* Aortic diameters obtained according to the two guideline recommendations at the aortic annuls, sinuses of Valsalva, sinotubular junction, and ascending aorta in 1,148 healthy adult volunteers were compared. Bland-Altman analysis, paired *t* tests, and intraclass correlation coefficients were evaluated at each segment. SIE values are reported as normative data, according to age, gender, and body surface area.

*Results:* The diastolic leading edge–to–leading edge convention yielded smaller diameters (compared with SIE) at the aortic annulus and ascending aorta and larger diameters at the sinus of Valsalva and sinotubular junction ($P < .001$ for all). There was excellent correlation between these techniques, with intraclass correlation coefficients of 0.88 to 0.96. Interobserver variability was minimal and similar for both techniques. Using the SIE technique, diameters were larger for men and increased with age and larger body surface area.

*Conclusions:* Although there was a statistically significant difference in aortic diameter measures between the two conventions used, this difference was very small and correlations were excellent, suggesting that the difference has no clinical significance. The authors recommend that a standard convention be adopted within the American Society of Echocardiography and across all professional cardiovascular imaging societies for consistency and improved communication. (J Am Soc Echocardiogr 2015;■:■-■.)

*Keywords:* Aorta, Aortic systolic dimensions, Guidelines, Chamber quantification

Aortic size has significant prognostic and therapeutic implications in patients with aortic disease. A dilated aorta requires close imaging follow-up because aortic diameter is the strongest predictor of catastrophic events such as dissection[1] and is used to determine appropriate timing for prophylactic surgery.[2,3] Therefore, accurate and standardized measurement techniques of the diameter of the thoracic aorta using various imaging modalities are of utmost importance. However, there is a lack of uniformity among experts regarding the methodology to be followed to perform such measurements using echocardiography.[3-8] Importantly, the American Society of Echocardiography (ASE) recommends different methodologies to be used for pediatric and adult patients. Although both guidelines recommend two-dimensional echocardiographic measurements to be performed in the parasternal long-axis view, they differ with regard to timing in the cardiac cycle and interface selection in performing aortic measurements. The guidelines for adult chamber quantification and multimodality imaging of the aorta recommend a diastolic leading edge–to–leading edge (DLE) technique,[5,7] while pediatric guidelines recommend a systolic inner edge–to–inner edge (SIE) technique,[8] a method also supported by the 2010 American College of Cardiology and American Heart Association guidelines.[3]

The magnitude of difference in terms of aortic dimensions as measured by the DLE and SIE techniques is unclear. A better understanding of this difference would be useful in an attempt to standardize techniques across all patient groups and in understanding potential clinical implications. In addition, normative data for the SIE technique in adults have been reported only in relatively small cohorts. The aims of this study were to report normal aortic diameters

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| Abbreviations |
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| **ASE** = American Society of Echocardiography |
| **BSA** = Body surface area |
| **DLE** = Diastolic leading edge–to–leading edge |
| **ICC** = Intraclass correlation coefficient |
| **SIE** = Systolic inner edge–to–inner edge |

in adults as measured by the SIE technique and to explore the magnitude of difference and correlation between the two measurement techniques (DLE and SIE) in a large population of normal individuals.

## METHODS

### Study Population

The population in this study consisted of consecutive healthy adult individuals (not meeting exclusion criteria as described below) referred to two hospitals in Italy (San Antonio Hospital in San Daniele del Friuli, Udine, and Cava de Tirreni-Amalfi Coast University Hospital, Salerno) for full screening of cardiovascular diseases from June 2007 to February 2014 and was described in detail by Vriz *et al.*[9] The screening evaluation included a physical examination, complete transthoracic echocardiography, and a thorough questionnaire about medical history, use of medications, cardiovascular risk factors, and lifestyle habits (alcohol intake, smoking, and physical activity). Three blood pressure measurements were obtained from the right arm, and the results were averaged to determine systolic and diastolic pressure. Body surface area (BSA) was calculated according to the formula of Du Bois and Du Bois ($0.20247 \times \text{height [m]}^{0.725} \times \text{weight [kg]}^{0.425}$).[10] Patients were excluded if they had any of the following conditions: coronary artery disease, systemic arterial hypertension, diabetes mellitus, morbid obesity (body mass index $> 30$ kg/m$^2$), significant valvular heart disease (any regurgitation or stenosis greater than mild), congenital heart disease, bicuspid aortic valve, congestive heart failure, cardiomyopathy, sinus tachycardia, or use of illicit drugs. Elite athletes and subjects with inadequate echocardiographic image quality were also excluded. The study was approved by the institution's ethics board, and informed consent was obtained from all participants.

### Echocardiography

Standardized transthoracic echocardiographic examinations were performed with commercially available equipment (Aloka $\alpha$10 [Aloka, Tokyo, Japan] and Vivid 7 [GE Healthcare, Milwaukee, WI]) as previously described.[9] All images were digitally acquired and analyzed offline using EchoPAC software (GE Healthcare). Left ventricular ejection fraction and left ventricular end-diastolic diameter were obtained according to ASE guidelines (biplane Simpson and two-dimensionally derived dimensions from the parasternal long-axis view, respectively).[6] With regard to aortic dimensions, images were obtained from a parasternal long-axis view and measurements performed from two-dimensional images, initially following the adult ASE guidelines (DLE; Figure 1A) at the level of the aortic annulus, sinus of Valsalva, sinotubular junction, and proximal ascending Aorta (at the level of the right pulmonary artery).[5-7,11,12] At a later time, the same aortic segments were remeasured in all subjects according to the pediatric ASE guidelines (SIE; Figure 1B),[8] blinded to the initial measurements performed using the adult ASE guidelines. In both instances, measurements were performed perpendicular to the long axis of the aorta in five consecutive beats and averaged.

Interobserver agreement was tested by remeasuring diameters with the DLE and SIE techniques in 100 randomly selected cases by two independent readers. Readers were blinded to each other, and they were allowed to select the cardiac cycles to be measured, but the average of five consecutive beats was recorded. Descriptive data on aortic dimensions as measured by the SIE technique were analyzed to serve as normative data for adults and presented as mean ± SD.

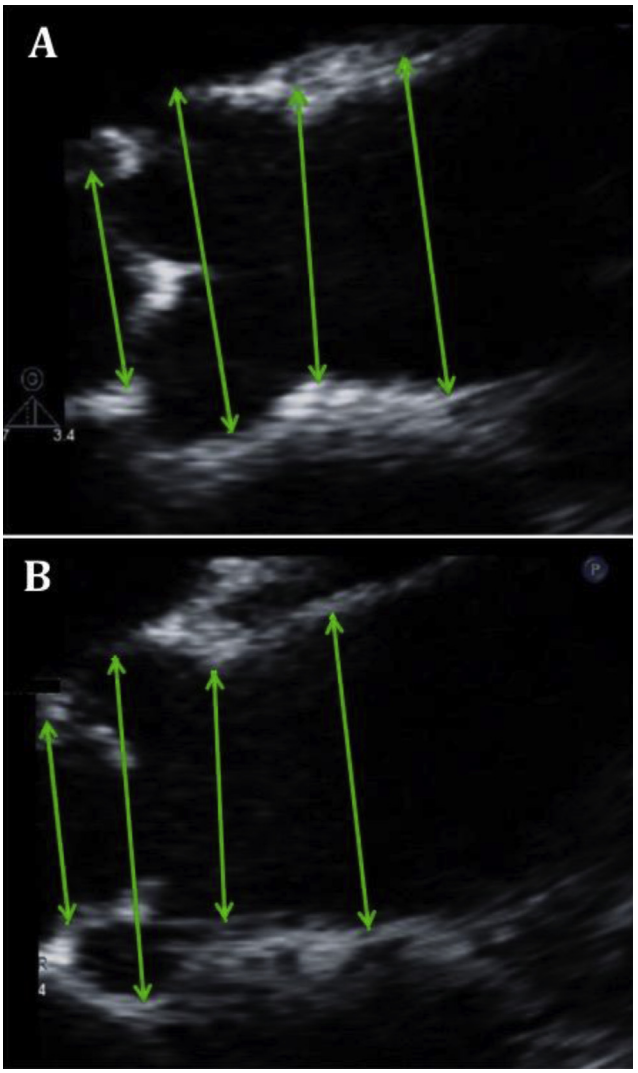


Figure 1 Ascending aorta measuring technique as recommended by the ASE guidelines for adults (DLE) **(A)** and pediatric patients (SIE) **(B)**. Note that adult guidelines recommend that measurements be performed in late diastole (aortic valve closed), including the anterior wall thickness (leading edge to leading edge, upper head of the caliper), while pediatric guidelines recommend mid-systole (valve is open), not including the anterior wall (inner edge to inner edge). *AAo*, Ascending aorta; *Ao* aorta; *LA*, left atrium; *LV*, left ventricle; *RPA*, right pulmonary artery; *RV*, right ventricle; *STJ*, sinotubular junction.[7,8]

### Statistical Analysis

To determine agreement between aortic measurements obtained by the DLE and SIE methods, paired measurements were compared at each aortic segment. Analyses at each of the prespecified aortic segments were carried out using Bland-Altman plots, the mean of absolute differences, paired *t* tests, and intraclass correlation coefficients (ICCs). An ICC of ≥0.8 indicated excellent agreement.