Editorial

Measuring the aorta in the era of multimodality imaging: still to be agreed

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Thoracic aortic dilatation is associated with major vascular complications with fatal consequences, such as dissection and aortic rupture. We can predict the risk of rupture or dissection based on aortic size (1,2). Broad spectrum of aortic complications benefits from different cardiac imaging techniques: transthoracic echocardiography (TTE), transoesophageal echocardiography (TOE), computed tomography (CT) and magnetic resonance imaging (MRI). Therefore, aortic dilatation is one of the most frequent clinical entities for request in cardiac imaging laboratories, both for the initial diagnosis and the monitoring and establishment of the optimal timing for surgery.

Despite the extensive literature published in this regard in the last years, the assessment of aortic diameters is still the sticking point in the era of multimodality imaging. Agreement in some technical issues is lacking and this is especially evident in the most recent extended techniques: CT and MRI.

The study by Asch *et al.* (3) recently published in *iJACC* with data from the GenTAC (National Registry of Genetically Triggered Thoracic Aortic Aneurysms and Cardiovascular Conditions) registry, aimed to evaluate the variability in aortic measurements comparing analysis results of clinical centres and a core laboratory. The study sought to focus on the impact of a standardized protocol for imaging studies interpretation of the aorta applied by a core laboratory.

This cross-sectional study over 965 imaging studies compare aortic measurements performed by TTE, CT and MRI at 6 clinical centres of excellence in genetically related aortic disease to those performed at the imaging core laboratory. Each clinical centre analysed the images according to local protocols and same images were analysed blindly by the core laboratory following a standardized protocol. Paired measurements from clinical centres and core laboratory were compared by mean of differences and intraclass correlation coefficient (ICC) as measure of consistency to determine the agreement between investigators.

Aortic segments available in less than 20 studies and aortic grafts were excluded from the analysis (21% had aortic root replacement, 18% ascending aortic replacement and 9% aortic arch replacement).

TTE demonstrated the best correlation for proximal aortic segments (aortic annulus, sinuses of Valsalva and ascending aorta) (ICCs 0.84–0.92). Mean differences were higher and ICC lower for measures performed using this technique for the aortic arch and descending aorta (ICCs 0.70–0.71). This is not surprising considering the greater technical difficulty involved TTE for the visualization of distal segments.

Regarding CT measurements, mean differences were greater than echo measurements for ascending aorta, up to 0.47 cm (ICCs 0.73–0.86).

MRI based measurements showed excellent correlation between clinical centres and core laboratory for all aortic segments (ICCs 0.82–0.95, mean of differences 0.002–0.12 cm) and demonstrated highest ICC for the arch and descending aorta. However, the number of MRI studies analysed was small, especially data available from proximal segments, limiting the achievement of more consistent

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results regarding this technique.

In an adjusted model significant variability was found among imaging modalities for sinuses of Valsalva (P<0.001), ascending aorta (P=0.018) and transverse arch (P=0.001). TTE yielded better agreement between centres and core laboratory investigators compared with CT and MRI (mean of differences ≤0.05 cm for sinus of Valsalva and ascending aorta) and there was no agreement differences related to the patient age group or diagnosis.

As expected for genetically entities, study population was young (35.5 years, 17.0–48.3). This fact could explain that interestingly only one of the six clinical centres enrolled performed aortic measurements by TTE in end-diastole and leading edge to leading edge (L-L), according to the last recommendations for the assessment of Thoracic Aorta in Adults from the American Society of Echocardiography and the European Association of Cardiovascular Imaging (4,5). Remaining clinical centres performed aortic measurements in systole and inner edge to inner edge (I-I), following the recommendations for paediatric population (6). Nevertheless, it seems to be greater degree of agreement when using TTE than other techniques by all the centres involved, possibly related to the greater experience with this technique.

Measurement approach regarding the inclusion or exclusion of the vessel wall is probably the most discussed topic about aortic measurement, but not the only. Sources of variability using multimodality imaging may be related to both acquisition issues and analysis protocols. Aortic pathologies often required long follow-up of the patient, preferably with the same imaging modality. Thus, measurement technique must be highly reproducible and intra and interobserver variability should be as low as possible. Technical issues related to the acquisition of CT and MRI as gated/non gated studies, slice thickness or contrast administration can be important sources of variability.

In summary, we should consider that the key questions to standardize and take into account when acquiring and analyzing a study of the aorta are the following:

(I) How to measure, related to the vessel wall: outer edge to outer edge (O-O), L-L, I-I;
(II) Where to measure: latest international recommendations propose a standardized segmentation for each level in the aorta. Specific location of performed measurements should be reference to a given anatomical landmark (4);
(III) When to measure, related to de cardiac cycle: systole or diastole;
(IV) What technique to use: best technique in each clinical scenario for the diagnosis and follow up of the patient, as each one has their pearls and pitfalls.

The discussion about how to measure thoracic aorta has been largely debated. Consensus have been changing parallel way with the development of ultrasound technology and the introduction of new imaging modalities in the last years in an attempt to make comparable measures performed with different imaging techniques. First established values for aortic diameters were taken on M-mode, L-L, and most of the longest datasets available were analysed following these indications. When last generation equipments with harmonic imaging and better axial spatial resolution were incorporated into clinical practice, new recommendations were adopted for measurements in 2 dimensions (2D), O-O. We have today available data that suggest that aortic diameters measured using L-L technique were significantly larger than those performed using I-I (5,7). Rodríguez-Palomares *et al.* (8) studied for the first time the correlation between diameters obtained by the three main methods on 2D TTE with those obtained by CT and MRI. They concluded that measures performed with I-I convention significantly underestimates the real diameter compared with measures performed by CT and MRI, with an excellent correlation when using L-L method. Best correlation was seen when using 2D TTE, L-L method, and internal diameters by CT and MRI. No evidence to date seems to be enough to change the initial convention L-L, and therefore current international guidelines recommend to use L-L method on 2D TTE, end-diastole, strictly perpendicular to the long axis, for all the aortic segments except aortic annulus (5). It is also important to consider age and body surface area related nomograms. When comparing these recommendations for adult with those different consensus for children, significant differences in aortic diameters were observed, although both methods showed good correlation and differences were very small, probably not clinically significant (9).

Asch *et al.* emphasize in their article that there was no uniformity in criteria for CT acquisition between the clinical centres enrolled, each one following each clinical preferences and personal experience, and only 30% of studies were electrocardiogram (ECG) gated. Mean differences between clinical centres and CORE laboratory measurements for CT were largest for sinus of Valsalva and isthmus, but when analysing only gated CT there was observed an improvement in agreement (ICC 0.84, mean difference 0.25 cm for the sinus of Valsalva; ICC 0.89, mean difference 0.11 cm for ascending aorta). ECG gated avoid motion artefact in thoracic aorta, especially in aortic root. Imaging artefacts often observed may appear as a double vessel wall, making

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estimation of the real diameter difficult or even confusing with a false image of an aortic dissection, favouring erroneous diagnoses (4). Interestingly, agreement for CT results was lower in distal segments, without technical reason being argued in this regard by the authors.

With regard to the interpretation of CT and MRI studies of aorta and other vessels, it is important to remember the need for correct alignment perpendicular to the axis of blood flow using the double-oblique technique with multiplanar reconstruction. Measures performed over axial planes comparing with double oblique planes may overestimate the real diameter because of aortic tortuosity, causing significantly higher results, which can have an impact on the diagnosis and surgical management of the patient (10).

Clinical experience and available research data with echocardiography are broader to date than those for CT and MRI, and greater degree of agreement have already reached. Similar consensus for CT and MRI for both acquisition and image analysis protocols is not available yet, so that the last guidelines for multimodality imaging try to start this route of standardization (4).

The article by Asch *et al.* reminds us once again of the need to work toward a consensus that allows us to work in a standardized and reproducible way, endorsed by international experts in the field and based on the results and conclusions of consistent scientific studies.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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