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EACVI COMMUNICATION

EACVI survey on standardization of cardiac chambers quantification by transthoracic echocardiography

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Aims To evaluate standard reporting of cardiac chambers size and function by transthoracic echocardiography (TTE), the EACVI Scientific Initiatives Committee performed a survey across European centres. In particular, the routine use of three-dimensional echocardiography (3DE) and speckle tracking-derived myocardial deformation imaging (STE) was explored.

Methods and results A total of 96 European Echocardiography Laboratories from 22 different countries responded to the survey, which consisted of 20 questions. For most of the standard parameters of cardiac chamber size and function, answers from the centres were homogeneous and demonstrated good adherence to current recommendations. In particular, all centres assessed left ventricular (LV) and left atrial (LA) size combining diameter measurements with volumes obtained using the bi-plane Simpson's method. More variability was observed in the measurements of the right heart chambers and thoracic aorta. Interestingly, >90% of centres had access to 3DE and STE; however, the large majority of centres reserved the use of these techniques for selected cases, particularly for the measure of 3D LV volumes and ejection fraction and global longitudinal strain in patients being considered for cardiac device implantation, surgical intervention (valvular heart disease) or screened for cardiotoxicity. Only 10% of centres used 3DE for right ventricular and LA volumes. Also, <30% of the centres used LA strain imaging.

Conclusion In Europe, a good adherence to current recommendations was observed for most of the standard parameters of cardiac chambers quantification by TTE. Advanced echocardiography modalities, such as 3DE and STE, are widely available but used only in selected cases.

Keywords cardiac chamber quantification • TTE • survey • EACVI • 3DE • GLS

Introduction

Quantification of cardiac chamber size and function represents a core element of all transthoracic echocardiography (TTE) reports. The introduction of two major technological developments in echocardiography, three-dimensional echocardiography (3DE) and speckle tracking-derived myocardial deformation imaging (STE), has significantly enriched the ability of this modality to assess cardiac

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structure and function, but has also challenged caregivers (cardiologist and non-cardiologists) to properly integrate these novel measures into routine clinical practice.

Standardization of image acquisition and analysis, as well as defining clear reference values for each parameter is of crucial importance in achieving uniformity in the interpretation and communication of the results of a TTE report. One of the main commitments of the European Association of Cardiovascular Imaging (EACVI), is 'to improve the standardization of cardiovascular imaging practice in Europe and to support knowledge sharing'. Accordingly, EACVI and the American Society of Echocardiography (ASE) have jointly prepared a series of documents to standardize cardiac chamber quantification by echocardiography, updating previous documents, and for the first-time including recommendations for 3DE- and STE-derived measures.[1–3] Based on these documents, the EACVI has also published in 2017 an expert consensus document which defined the key quantitative information related to cardiac structure and function to be included in a standard adult TTE report.[4] However, depending on the internal organization, workload, financial resources, expertise, and patient population, each echo lab may report the TTE findings differently and vary in their ability to integrate novel measurements alongside traditional assessments.

The aim of this survey from the EACVI Scientific Initiatives Committee was therefore to evaluate the standard reporting of cardiac chambers size and function across different European centres in the EACVI survey network and investigate whether and when 3DE- and STE-derived measures are included in standard TTE reports.

Methods

The present survey was conducted by the EACVI Scientific Initiative Committee from 19 June to 12 July 2019 according to the criteria previously described[5,6] (www.escardio.org/eacvi/surveys). A total of 150 European Echocardiography Laboratories were invited to complete an online survey investigating which parameters (and their reference values) were used for cardiac chamber quantification in standard TTE reports. The survey consisted of 20 questions aimed at understanding the available facilities and workload of each centre, and the key measurements implemented in their routine clinical practice, including the use of 3DE and STE. Most questions were yes/no or multiple-choice, but on occasion free text answers were possible allowing more detailed explanation, particularly regarding in which specific patients and clinical context certain measurements are applied.

Results

Characteristics of responding centres

In total, 96 (64%) centres from 22 different countries responded to the survey. Responding centres were located in: Belgium (11), Croatia (3), Denmark (1), France (4), Germany (4), Greece (1), Hungary (5), Italy (9), Lebanon (2), Macedonia (3), Malta (2), Netherlands (5), Norway (6), Poland (9), Portugal (4), San Marino (1), Slovenia (7), Spain (9), Sweden (1), Switzerland (3), Turkey (3), and UK (3).

Most centres were tertiary centres or University Hospitals, providing a high-volume service (40% of centres performed >300 TTEs per week whilst only 11 centres did ≤100 TTEs per week). Of interest, half (48%) of the centres worked with sonographers, and in a quarter (27%) sonographers performed the majority of the scans in the echo lab. Half (52%) the centres worked with two different ultrasound vendors and 18% with three or more; 91% of centres had access to digital echocardiographic archiving, with the majority of the remaining centres still able to perform advanced echocardiographic analysis on the scanner.

Availability and application of advanced echocardiographic modalities

The large majority of the centres (95%) answered that 3D echocardiography was available in their echo lab, although most of them were only using it in specific cases or during transoesophageal echocardiography (*Figure 1A*). When asked to elaborate regarding the specific applications, most centres used 3DE for the accurate quantification of left ventricular (LV) volumes and ejection fraction (EF) when making decisions regarding (i) device implantation (implantable cardioverter-defibrillator or cardiac resynchronization therapy), (ii) surgical interventions (for valvular heart disease), and (iii) for the assessment of cardiotoxicity in oncological patients; only two centres mentioned the use of 3DE during stress echocardiography.

Similarly, STE was available in 96% of centres, but used mainly (60%) in selected cases rather than as a routine measurement (*Figure 1B*). The most frequent indication was suspicion of LV dysfunction in the presence of preserved LVEF, such as in patients on chemotherapy, with cardiomyopathy, valvular heart disease, or heart failure with preserved EF; only two centres used STE for the assessment of LV dyssynchrony.

The left ventricle

LV diameter and wall thickness were reported routinely in all centres and were derived from 2D parasternal views rather than M-mode in 86% of sites (15 centres used a combination of 2D and M-mode measures). Similarly, LV volumes and EF were reported routinely in 92% of centres using the bi-plane Simpson's method, with 35% of centres using semi-automated software to perform this measurement. Of interest, 38% of the centres did not index LV volumes for body surface area (BSA). When asked whether 3DE was used to assess LV volumes and EF, 30% of the centres answered negatively, with 12% explaining that this was because they did not believe in the additional value of this approach. Also, among the 67 centres using 3DE 37% did not apply the adapted cut-off value for 3DE measures suggested by EACVI recommendations. 3DE-derived LV volumes and EF were most frequently measured in cardio-oncology cases or where 2D measures of LVEF were borderline but crucial for the clinical decision-making such as for device implantation indication or the diagnosis of cardiomyopathy. Among the comments, the limitations mentioned for 3DE included image quality and operator dependency.

Similarly, 96% of centres used LV global longitudinal strain (GLS) derived from STE to measure LV function, but this was reserved for selected cases including patients on chemotherapy or those with cardiomyopathy, valvular heart disease, or heart failure with preserved EF. Of interest, when GLS was measured, 65% of the centres used the reference value of -18%, whilst the remainder used -20%. Several

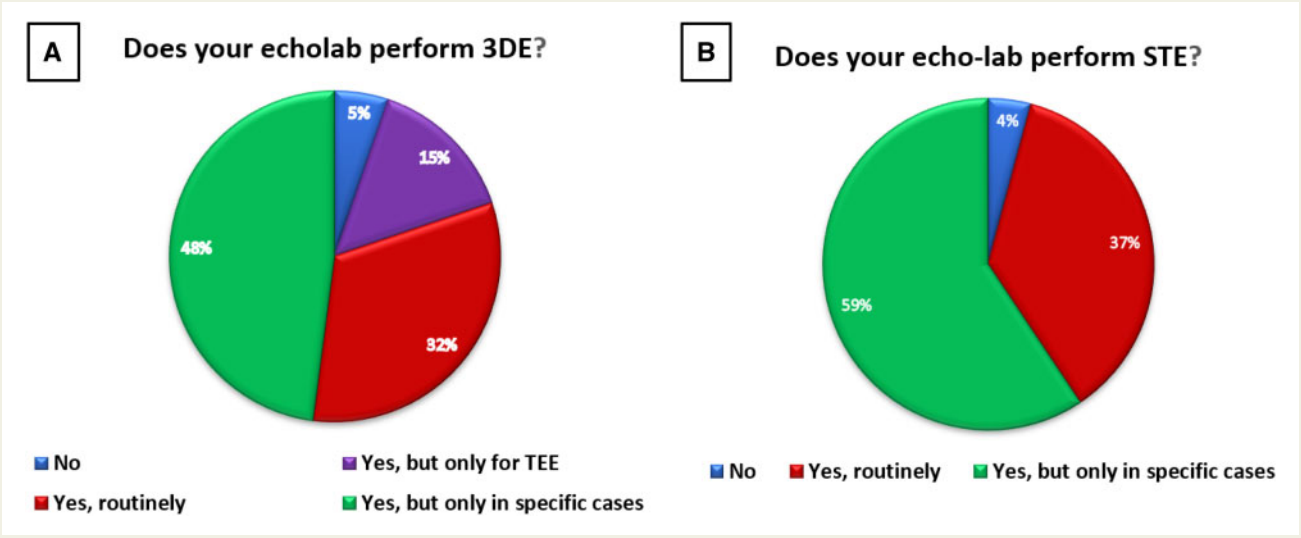

Figure 1 Use and availability of advanced echocardiographic modalities. (*A*) Three-dimensional echocardiography (3DE). (*B*) Speckle tracking-derived myocardial deformation imaging (STE).

centres highlighted the limitation of variation in GLS measurements between different vendors.

Finally, regional wall motion abnormalities were routinely described in all centres but wall motion score index (wmsi) was not included in the standard report in 60% of the centres. In the other centres (40%), wmsi was calculated only in cases of coronary artery disease or ischaemic cardiomyopathy. The majority used a 16- or a 17-segment model, only four centres used the 18-segment model.

The atria

Left atrial (LA) size was systematically reported in the standard TTE report in all centres. As compared to a qualitative description (dilated or not), 55% of centres routinely provided a quantitative assessment. This included the LA volume index in 74% of centres (of which 55% used the bi-plane method, 25% used only the 4-chamber apical view, and 20% used 3DE) and the LA antero-posterior diameter from the parasternal long-axis view in 45% of centres. Importantly, 68% of centres did not use STE-derived LA strain as a measure of LA function. When LA strain was measured, 93% of the centres assessed the reservoir function, while 34% the conduit function and 48% the contraction function (*Figure 2*).

In 46 centres (49%), right atrial (RA) size was not included routinely in the TTE report and in 14 (14%) was only described qualitatively. When measured, the following parameters were used: (i) the 2D derived RA volume from the 4-chamber view (51%), which was indexed to BSA in 26% of centres; (ii) the RA diameters from the 4-chamber view (23%).

The right ventricle

Right ventricular (RV) size was routinely reported in 86% of centres, among which 37% provided a qualitative assessment of whether the RV was dilated or not, whilst 63% provided quantitative measurements. A dedicated RV focused view was used in 61% of centres. Quantitative measures of RV size were used as follows: basal diameter of the 4-chamber view in 71% of centres; mid-cavity diameter on the 4-chamber view in 32%; and proximal and distal RV outflow-tract diameter in 29% and 17% of centres, respectively. Only 10% of the centres measured RV volumes by 3DE.

RV function was systematically reported in the standard TTE report in 96% of centres with a qualitative description in 26%, and quantitative measurements provided in 70% of the centres. The most used quantitative measurements of RV function were tricuspid annular plane systolic excursion (TAPSE) (91%), and the tricuspid valve annular systolic (s′) velocity by tissue Doppler imaging (73%), while RV fractional area change was used in 31% of centres and RVEF by 3DE in only 12%.

The aorta

The dimensions of the thoracic aorta were reported routinely in 92% of centres. The aortic root and the proximal ascending aorta were measured in 75% and 81% of centres, respectively, whilst the aortic annulus was measured in 56% and the aortic arch in 42% of centres. Interestingly, the method used to measure the aortic size varied significantly between centres (*Figure 3*).

Discussion

The present EACVI survey involved almost 100 centres from 22 European countries and reports on the parameters for chamber quantification currently included in standard clinical TTE reports. Importantly, this survey also explored the use of advanced echocardiographic modalities such as 3DE and STE in the routine clinical practice across different European echo labs.

Most of the respondents were from tertiary centres or university hospitals with a high volume of patients, and the findings of this survey may therefore not be generalizable to other clinical environments.

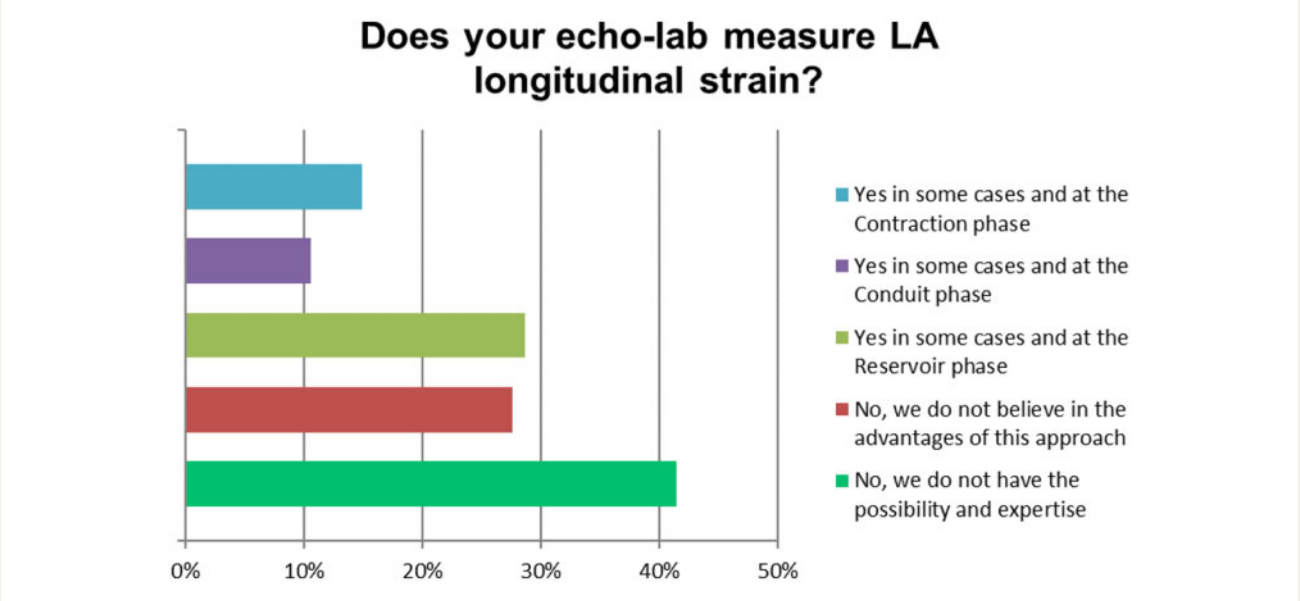

Figure 2 When and how left atrium (LA) longitudinal strain is measured.

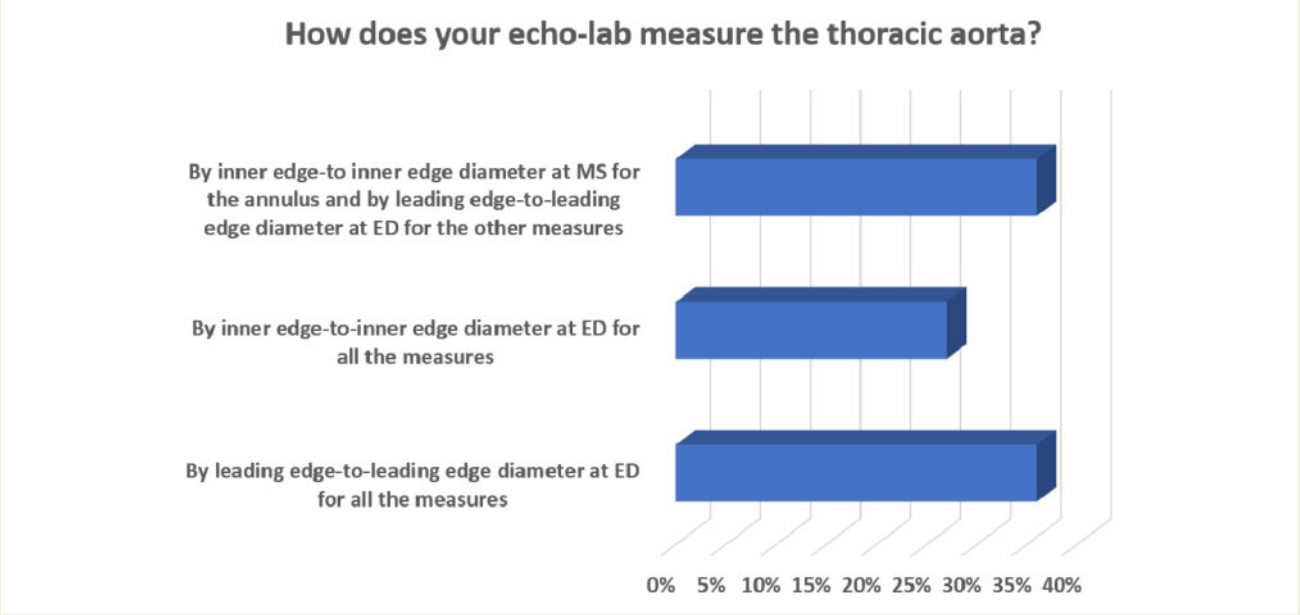

Figure 3 Diverse methods to measure the thoracic aorta dimensions. ED, end diastole; MS, mid-systole.

Standard parameters

For most of the standard parameters of cardiac chamber size and function, the answers from the centres were relatively homogeneous and demonstrated good adherence to current recommendations. For example, almost 100% of centres assessed LV and LA size combining diameter measurements (mostly from 2D rather than M-mode) with volumes obtained using the bi-plane Simpson's method. Interestingly, 35% of centres had access to semi-automated software to help with these volume measurements. Only 60% of centres indexed LV and LA volume to BSA.

More variability was observed in the approach to measurements of the right heart chambers and thoracic aorta. To assess RV size, centres measured RV diameters at different positions in the ventricle: basal, mid, or of the RV outflow tract, whilst RV function was largely measured using simple assessments such as TAPSE (90%) and s′ (70%). These observations likely reflect the challenges of assessing

such a complex chamber and the unresolved problem of finding accurate and easy to use parameters for the RV (and RA).

Quantification of thoracic aorta diameters was performed in all centres but with significant variation in the approach of measuring. Current recommendations suggest measuring the aortic annulus by inner edge-to-inner edge diameter in mid-systole, while all other measurements (aortic root and ascending aorta) should be taken using leading edge-to-leading edge convention at end diastole. However, the switch to the inner edge-to-inner edge approach for all measures by echocardiography was considered by the recommendations document to reach uniformity with other imaging modalities (namely computed tomography). The results of the survey, showing that all three different strategies are evenly used in common practice, likely reflecting local preference and familiarity with computed tomography.

Advanced echocardiographic techniques

More than 90% of centres had access to 3DE and STE, suggesting the wide availability of these modalities in most of European echo labs. However, the large majority of centres appear to reserve the use of these techniques for selected cases and specific indications. The most frequently mentioned applications were in patients requiring particularly accurate quantification of LV dimensions and function including those being considered for cardiac device implantation (implantable cardioverter-defibrillator or cardiac resynchronization therapy), surgical intervention (for valvular heart disease) or being screened for cardiotoxicity whilst receiving chemotherapy. This approach is supported by the published scientific literature and current guideline recommendations.[1] Only few centres mentioned the use of STE or 3DE for the assessment of LV dyssynchrony, again consistent with current guidelines which do not recommend these measurements.[7] Interestingly, despite the widespread availability of these techniques the current survey showed that almost 40% of centres did not apply specific reference values for 3D-derived LV volumes. Also, we observed variation in the cut-off valve of GLS for normality (two-thirds used -18% and one-third -20%) reflecting the fact that in the initial recommendation document the value of -20% was given,[1] while the latest expert consensus document suggested a range from -18% to -22%.[4]

It was also unexpected to report that, despite growing evidence in the literature of their additional value, only 10% of centres use 3DE for the assessment of RV and LA volumes. This observation probably reflects the lack of dedicated software (as compared to the LV) for this assessment; similarly <30% of the centres used LA strain imaging.

Overall, further research is required to investigate whether advanced echocardiographic techniques such as 3DE and STE can improve the assessment of cardiac structure and function as well as patients care and outcomes. Ultimately these would ensure wider adoption of these advanced modalities. Other areas that require further work and research include the (i) education of sonographers and cardiologists in appropriate image acquisition and analysis to allow accurate post-processing and robust results, (ii) automatization of measurements in order to facilitate fast and simple daily use and improve reproducibility and feasibility, and iii) definition of more robust reference values and standardization of values between different vendors (especially considering most centres appear to use two or more different vendors within the same echo lab).

Certain topics, such as the use of echo contrast or the application of advanced quantification during stress echocardiography, were not included in the present survey.

Conclusions

In Europe, a relatively homogenous adherence to current recommendations was observed for most of the standard parameters of cardiac chambers quantification. Advanced echocardiography modalities, such as 3DE and STE, are widely available but were used only in selected cases. Efforts should therefore be made by the echocardiography community and by EACVI to define where wider expansion of these techniques is warranted and to further promote standardization and proper training across all centres.

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Conflict of interest: none declared.

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