

EDITORIAL

Challenges and opportunity in the era of quantitative echocardiography

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Summary

The advancement of echocardiography in the past two decades is more than downsizing of the machines and improvement of image quality, but introduction of new imaging modalities leading to the ability of performing quantitative analysis. This function is greatly facilitated by the integration of echo machines with high performance computers, software programming and establishment of workstation for offline analysis. Today, echo examination is more than estimation of ejection fraction (EF) and patterns of left ventricular (LV) diastolic dysfunction. Echocardiographers are facing a large number of quantitative parameters for interpretation. In newer imaging modalities such as tissue Doppler imaging, speckle tracking, 3-dimensional echocardiography and 3D-transoesophageal echocardiography, quantitative echocardiographic assessment has important roles. These have brought many opportunities but also challenges in our echo practice.

Key Words

- ▶ quantitative echocardiography
- ▶ echocardiographic quality

Opportunities

Clinical values of quantitative echocardiography

Traditionally, measurement of EF is the bread and butter of echo and is being one of the most widely accepted methods (1). However, there is a large variation of EF values by different echocardiographic methods, and being most accurate by 3D echo while most inaccurate by M-mode. An accurate value of EF is crucial in clinical decision making. For example, a heart failure patient with a measured EF of 30% should receive a heart failure device therapy (ICD vs CRT), whereas a measured EF of 36% has fallen out the threshold of such therapy, and the latter could have been contributed by the use of less accurate methods (2). Accurate measurement of EF may allow physicians to monitor treatment effect (such as medical treatment, device or surgical therapy) by serial follow-up echocardiographic assessment, as well as estimation of patient prognosis. Recently, the incorporation of artificial intelligence into the echo system will further enhance the

ability of automated measurement of LV volume in a 3D manner. This will further improve the reproducibility of EF measurement.

There are new quantitative measurements of LV systolic function, such as mean tissue Doppler systolic velocity of the basal LV segments or mitral annulus, peak systolic 2D and 3D strain-derived parameters (3). The merits of these new parameters are that they permit the assessment of both global and regional LV function, some of them are proven to be more sensitive in detecting subclinical myocardial dysfunction and may have stronger or incremental prognostic value than EF alone, in particular in the presence of systolic dysfunction and after myocardial infarction (4, 5).

With the incorporation of quantitative tools, the assessment of LV diastolic function is no more qualitative. Most of the credits belongs to TDI, which defined the pseudonormal pattern with reduction of mitral annulus

E' velocity, the estimation of filling pressure by E/E' and the combined quantitative measurement of many parameters of diastolic filling such as pulmonary vein atrial reversal velocity, time difference between transmitral A wave and atrial reversal wave and atrial volume. With the combined use of other parameters of filling pressure, physicians and intensivists are now confident to estimate sick patients' fluid status with rarely necessitating the insertion of central venous line or Swan-Ganz catheter at ICU and CCU. Furthermore, these newer quantitative tools have been proven to carry additional prognostic values on top of conventional parameters (4).

Furthermore, systolic mechanical dyssynchrony of the left ventricle can readily be assessed by the novel echo tools, including tissue Doppler imaging, speckle tracking and 3D echo (5). This has the implication of predicting response to cardiac resynchronization therapy (6). Furthermore, diastolic dyssynchrony can also be readily assessed by tissue Doppler imaging (7).

There are many other quantitative analysis tools that can match the demand on the increasingly complex assessment of cardiac structure and function on a day-to-day basis. This range from assessment of right ventricular volume and systolic and diastolic function, atrial mechanical function and stiffness, LV workload and stress, TEE assessment of mitral apparatus anatomy and valvular dysfunction for guidance of treatment modalities, assessment of severity of valvular stenosis and regurgitation, estimation of pressure gradient and flow volume across chambers and shunts and lately dedicated software for aortic assessment for planning of TAVI. It is advisable that any established echo-lab should have trained experts who are able to apply most of these skills for patient care. In highly specialized areas that need detailed assessment, such as pre-TAVI assessment, mitral regurgitation assessment pre-mitral clip or complex 3D assessment of mitral apparatus by dedicated software, referral to specialized experts is advisable (8).

Quantitative echo in research arena

Nowadays echo is an indispensable tool for cardiovascular research. It is the most commonly employed non-invasive tool for the assessment of cardiac structure and function. In clinical trials, in particular therapeutic trials, echocardiographic parameters can be used to determine treatment effect and its significance and as primary end points (9). For example, serial assessment of changes of EF and LV remodeling by 3D echo facilitates the

determination of whether a particular pacemaker or heart failure treatment device is clinically effective. In trials of valvular repair or replacement, TAVI and mitral clip therapy, echo assessment of valvular gradient, valvular area and regurgitation reveals treatment success and has prognostic significance. Furthermore, in structured clinical trials, offline echo assessment should be carried out by the echo core-lab that is experienced to the echo parameters being measured, and in a blinded fashion. This will enhance the credibility of the clinical trial and generate more conclusive interpretations.

The above modality of research needs a multidisciplinary approach with close collaboration between echocardiographers, clinical trialists, physicians and cardiologists subspecialized in particular fields.

On the other hand, as echo tools are undergoing rapid development and new tools are often quantitative in nature, there is a continuous trend of increasing number of echocardiographic research. This usually involves the validation of new echo technologies against other imaging modalities (e.g. CT, MRI, radionuclide imaging, or sometimes invasive imaging), the exploration of their roles in the diagnosis, monitoring or prognosis for various cardiac diseases, or even trying to supersede their roles from traditional echo parameters. Since currently these studies are largely single-centre trials, from the scientific point of view, it is highly recommended that multicentre studies are carried out to validate the usefulness of these new tools on a broad population basis.

Challenges

Meet the clinical demands

Echocardiography scanning and interpretation is increasingly complex and time consuming, and with the shifting to more and more quantitative analysis, the number of parameters need to be measured is progressively increasing. Therefore, echo labs need to adopt a well-designed protocol with inclusion of both traditional and new parameters and also depending on the clinical problems faced. In some countries, patient load is huge when echocardiographic manpower is limited, in particular in Asia. As a result, the allocated echo scanning and reporting time could be exceedingly short. The evolution of using automated algorithms for quantitative analysis instead of relying on manual tracing will help to substantially reduce the measurement time.

To train the most appropriate specialists to conduct echo examination is another important practical issue. In some countries, echo was performed by ultrasound specialists instead of cardiologists. While ultrasound doctors were able to learn traditional echocardiographic methods, the advanced echo technologies may fall beyond their scope of cardiac knowledge and hence adoption of new echo technologies will be slow or even limited.

While physicians are interested to incorporate new and powerful echo technologies to assist the diagnosis and management of their patients, the actual usage could be limited by the vendor-specific nature of these tools. For example, in TDI and speckle tracking analyses, both the online echo data acquisition and offline analysis algorithms are vendor specific. Furthermore, inter- and intra-observer variabilities could have been different and in fact the validation process may not be identical. As a result, tissue Doppler velocities and strain values measured from one vendor may be very different from another vendor. Let us take 2D speckle strain as a further example. One vendor may be strong in measuring longitudinal strain while the other is good at radial strain, but combining the strain analysis of two vendors may not be complementary and obviously too time consuming and costly. Currently, vendors are trying to improve their algorithms to close the gap of such limitations and hopefully reduce inter-vendor variabilities. It might still take some time before echo vendor can truly working join-handed to perform cross-validation for new tools among vendors and determine common standards for users to follow. The bottom line is, these new quantitative tools need to be robust enough with small margin of variabilities before they can be widely accepted for clinical usage.

Conduction of high quality clinical trials

While the echo tools are getting more and more complicated, the concept of using new quantitative parameters on clinical basis could have been oversimplified. For a new quantitative echo parameter to be used in clinical practice, a cutoff value has to be well defined to delineate abnormality. For example, what are the average cutoff values for mean longitudinal systolic strain by 2D speckle analysis and mitral annulus early diastolic velocities? Although previous single-center studies might have tried to map out such cutoff values from their database, it is only representative of a specific patient group, such as certain age range and ethnic group. However, the differences attributable to genders, heart

rate and possibly other confounding factors had not been addressed. Therefore, large international multicenter studies are needed to address these issues and define cutoff values of quantitative parameters specific to age group, gender and ethnic differences. Future researches should also address the vendor difference in the measured values including the cutoff values of the same quantitative parameter.

While soliciting research funding is increasingly difficult, this hurdle is even higher for developing new echocardiographic tools when compared with the development of new drugs or new therapeutic devices. In general, the research and development fund from vendors for development of new drugs or devices are usually far greater than that of new echo technologies. As a result, clinical trial for validation of new echo tools are usually single centre in nature, relatively small in sample size and limited to specific patient features. Furthermore, when intra- and inter-observer variabilities are studied, they are usually performed on the same pre-recorded high-quality images instead of acquiring another new set of echo images from the same and then from different operators. This could have significantly alleviated the true variabilities expected from the new tools.

Finally, for new quantitative parameters that are found useful and is going to be published, the methodology for online image acquisition and offline analysis should be described in technical details to an extent that readers and clinical researchers are able to follow comprehensively. Currently, methodology section is usually brief and mainly described the key settings of online acquisition and main principles of offline analysis. However, in actual research world, there are many variations in analysis apart from obviously normal and obviously abnormal features. It is the responsibility of the publishing authors to provide clear guidance and even protocol on how to generate the results and interpretations. To cater the publication space limits, these practical and essential information could be published as an appendix and be accessible on the Web-based format. Editors of journals should request this in the check-list for manuscript submission. By increasing the transparency of skill and knowledge transfer, new tools can excel shall they be eventually found useful.

Training and accreditation of new echo technologies

Training and accreditation is a fundamentally important concept and practice in medical training, in particular

when acquiring new skills and knowledge. Although there are established training and accreditation requirements for traditional transthoracic and transoesophageal echocardiographic practice, this has not been well defined to new echocardiographic technologies. In contrast, new and quantitative echo tools are gradually integrating into clinical practice, being widely used in echo research arena, as well as adopted by echo core-lab. Such unrestricted usage is not recommended and could be potentially harmful since lack of proper training may result in suboptimal image acquisition and/or inaccurate measurement leading to misinterpretations. Furthermore, lack of proper training will result in high inter- and intra-observer variability of the parameters being measured, and damage the credibility of a potentially useful clinical tool (10). In order to ensure a proper adoption of a new echocardiographic tool for either clinical usage or research application, the following pathways is highly recommended. Firstly, pioneers of the field should publish the detailed methodology of online image acquisition and offline analysis as mentioned. Secondly, experts captured a new technology should work together to create a guidance for training and accreditation. Thirdly, echocardiographic vendors should be aware of the need of training and accreditation and ensure that such process is in place when new technologies are being introduced to institutions. With the empowerment of high-quality and reproducible work through proper education and training, quantitative echocardiography will have a bright future in both clinical and research application.

Declaration of interest

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