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Editorial

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Clinical Implication (Application) of Measurement of LV Function by Three-Dimensional Speckle-Tracking Echocardiography: Three-Dimensional Myocardial Strain for the Prediction of Clinical Events in Patients With ST-Segment Elevation Myocardial Infarction

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▸ See the article "Three-Dimensional Myocardial Strain for the Prediction of Clinical Events in Patients With ST-Segment Elevation Myocardial Infarction" in volume 30 on page 185.

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Assessment of global left ventricular (LV) systolic function has an important role in assessing the prognosis of a variety of cardiac diseases, and also influences treatment strategies.[1)] The most widely used parameter is LV ejection fraction (EF), and this is commonly obtained by echocardiography. However, this has a number of important limitations, including geometric assumptions, load dependency, reproducibility, inter-observer variability, and the influence of heart rate and beat to beat variability (e.g., atrial fibrillation).[2)]

So recently, speckle-tracking echocardiography (STE) is a novel imaging modality that allows quantitative assessment of global and segmental LV myocardial function by measuring LV strain in a manner largely independent of angle and ventricular geometry.[3)]

In a previous study, because subendocardial fibers are most susceptible to injury, subclinical LV impairment may be identified by reduced longitudinal function.[2)] Therefore, myocardial deformation measurements by STE allow early diagnosis of LV dysfunction by facilitating better risk stratification, reclassification and treatment in patients with cardiovascular disease.[4)]

And, because a two-dimensional (2D) myocardial strain index such as global longitudinal strain (GLS) can be obtained using speckle tracking and other post-processing techniques, the patient's actual infarct size can be accurately assessed while maintaining appropriate temporal resolution.[5)] Moreover, myocardial strain is not only useful in evaluating myocardial viability and predicting future ventricular remodeling,[6)7)] but also in assessing the prognosis. Patients with reduced end-systolic GLS values are at a greater risk for major clinical events, such as cardiac death or re-hospitalization due to heart failure.[8-10)] This association persists even after adjusting for other significant risks factors.[11-13)]

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Conflict of Interest

The author has no financial conflicts of interest.

However, 2D strain imaging has some inherent limitations. Strain information obtained from different image sections must be integrated in order to calculate the global strain value of the entire LV.[5)] Therefore, it is impossible to assess the global strain using the images obtained in the same cardiac cycle, and it takes a relatively long time to measure the strain value. In addition, the three-dimensional (3D) motion of the myocardium is analyzed on a 2D plane, the so-called 'out-of-plane' phenomenon occurs. Because the target segment does not remain in the same cross-sectional plane during a given cardiac cycle, this is particularly prominent when processing circumferential or radial strain using short-axis images.[14)]

3D echocardiography is considered to overcome these shortcomings. As the 3D volumetric data of the entire ventricle can be obtained with a multiarray transducer, 3D strain analysis has begun to be applied in the field of clinical echocardiography. Many manufacturers provide semi-automated tools to easily apply 3D imaging. Therefore, 3D-STE has the potential to overcome some of the intrinsic limitations of 2D-STE in the assessment of complex LV myocardial mechanics, offering additional deformation parameters (such as area strain) and a comprehensive quantitation of LV geometry and function from a single 3D acquisition.[15)] Therefore, compared to 2D-STE, there are advantages of 3D-STE. First, 3D-STE has also been shown to provide a faster and more complete assessment than 2D-STE, overcoming some of the shortcomings of previous techniques by reducing the intraobserver and interobserver variability inherent in 2D measures and avoiding the angle dependence of strain and strain-rate measures obtained on Doppler tissue imaging.[16)] Second, since LV deformation involves a combination of apex-to-base movement, thickening, and simultaneous twisting, speckles exhibit genuine 3D motion, which 2D-STE cannot account for as compared to 3D STE (**Table 1**).[15)]

However, although we could obtain various 3D strains, LV mass, LV volume and EF simultaneously, the use of 3D strains has some inherent drawbacks.

Table 1. Comparison between 2D and 3D speckle-tracking analysis of LV myocardial strain[15)]

Characteristics	3D strain	2D strain
Acquisition	One apical 3D full volume	Three parasternal and three apical 2D views
Heart rate	Regular (6-beat LV full volume)	Regular (consecutive 2D LV planes)
Feasibility in sinus rhythm	Good	Very good
Reliance on good image quality	Yes (++)	Yes (+)
Temporal resolution (volumes/s)*	34–50	40–80
Parameters	All strains (longitudinal, radial, circumferential)	All strains (longitudinal, radial, circumferential)
Two-directional (area) strain†	Yes	No
Bull's-eye map‡	Dynamic	Static
Calculation of global strain	Simultaneous segmental values§	Non simultaneous segmental peaks§
Radial strain	Calculated from area strain (by the law of volume conservation)	Measured
Out-of-plane motion of speckles	No	Yes
Positive peak rule‖	No	Yes
Drift compensation¶	No	Yes
Definition of end-systole	Time of LV minimal volume	Time of aortic valve closure

LV: left ventricular, 2D: two-dimensional, 3D: three-dimensional.
*A higher range is advisable in tachycardia to avoid undersampling (40% of the heart rate).
†Reflects a combination of longitudinal and circumferential strain.
‡Bull's-eye maps of 2D longitudinal strain display one snapshot with peak values of segmental strain; bull's-eye maps of 3D strain parameters display simultaneous segmental strain values continuously throughout the cardiac cycle.
§With 2D longitudinal strain bull's-eye, peak segmental values are displayed irrespective of their reciprocal timing during systole; with 3D strain bull's-eye, simultaneous segmental strain values are displayed in each frame.
‖In the bull's-eye display, positive strain is displayed during systole for a certain segment only if the positive peak strain exceeds 75% of the peak negative strain value in the same segment.
¶All segmental strain curves are "forced" by the software to return to baseline at end-diastole.

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First, limited temporal resolution is a well-known limitation of 3D-STE, when compared with 2D-STE. In general, the reported frame rate for 3D-STE is lower than that for 2D-STE, and the recommended frame rate for 3D-STE is 40–80 Hz.[17] Second, in general, 3D datasets are comprised of multiple sectors, and stitching noise may be caused around the border between sectors. Therefore, the temporal resolution of 3D imaging is relatively low, which may be of concern as far as the accuracy of the measurement.[14][18]

So, the normative range of 3D-GLS was significantly lower than with 2D-GLS. However, Comparing the 2D-STE and 3D-STE of the GLS measurement method, which is the most convincing evidence of the LV deformation parameter, 3D-GLS demonstrated significant correlation with 2D-GLS.[19][20]

Therefore, recently, studies related to evaluation of LV and right ventricular (RV) function by 3D-STE have been reported. Also, studies related to evaluation of subclinical myocardial dysfunctions in aortic valve stenosis patients by 3D-STE and studies related to assessment of coronary artery disease severity in patients of stable angina pectoris by 3D-STE have been reported.[21][22]

But, compared with 2D strain imaging, 3D strains imaging has relatively low sampling rate and spatial resolution, and the standardization of the image processing algorithms has not yet been established.[14][19][23]

Therefore, study of 3D myocardial strain for the prediction of clinical events in patients with ST-segment elevation myocardial infarction is meaningful in that it is rare large-scale studies.

So, in the future, additional large-scale studies are needed to verify the prognostic power of the 3D strain analysis and to utilize the 3D strain index as an effective prognostic factor.

In addition, large-scale studies on the normal baseline range of LV and RV deformation by 3D-STE are also needed.

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