

Editorial



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

Eun Jeong Cho , MD, PhD

Division of Cardiology, Department of Internal Medicine, Heart Brain Hospital, Chung-Ang University Gwangmyeong Hospital, Chung-Ang University College of Medicine, Gwangmyeong, Korea

OPEN ACCESS

Received: May 9, 2022

Revised: Jun 14, 2022

Accepted: Jun 23, 2022

Published online: Jul 8, 2022

Address for Correspondence:

Eun Jeong Cho, MD, PhD

Division of Cardiology, Department of Internal Medicine, Heart Brain Hospital, Chung-Ang University Gwangmyeong Hospital, Chung-Ang University College of Medicine, 110 Deokan-ro, Gwangmyeong 14353, Korea.
Email: ounjungcho@hanmail.net

Copyright © 2022 Korean Society of Echocardiography

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<https://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ORCID iDs

Eun Jeong Cho 

<https://orcid.org/0000-0003-3345-2516>

► 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.

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.^{8,40)} This association persists even after adjusting for other significant risks factors.^{11,13)}

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 strain¹⁵⁾

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.

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.

REFERENCES

1. McMurray JJ, Adamopoulos S, Anker SD, et al. ESC guidelines for the diagnosis and treatment of acute and chronic heart failure 2012: the task force for the diagnosis and treatment of acute and chronic heart failure 2012 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association (HFA) of the ESC. *Eur J Heart Fail* 2012;14:803-69.
[PUBMED](#) | [CROSSREF](#)
2. Nesbitt GC, Mankad S, Oh JK. Strain imaging in echocardiography: methods and clinical applications. *Int J Cardiovasc Imaging* 2009;25 Suppl 1:9-22.
[PUBMED](#) | [CROSSREF](#)
3. Voigt JU, Cvijic M. 2- and 3-dimensional myocardial strain in cardiac health and disease. *JACC Cardiovasc Imaging* 2019;12:1849-63.
[PUBMED](#) | [CROSSREF](#)
4. Cikes M, Solomon SD. Beyond ejection fraction: an integrative approach for assessment of cardiac structure and function in heart failure. *Eur Heart J* 2016;37:1642-50.
[PUBMED](#) | [CROSSREF](#)
5. Gorcsan J 3rd, Tanaka H. Echocardiographic assessment of myocardial strain. *J Am Coll Cardiol* 2011;58:1401-13.
[PUBMED](#) | [CROSSREF](#)

6. Mollema SA, Delgado V, Bertini M, et al. Viability assessment with global left ventricular longitudinal strain predicts recovery of left ventricular function after acute myocardial infarction. *Circ Cardiovasc Imaging* 2010;3:15-23.
[PUBMED](#) | [CROSSREF](#)
7. Antoni ML, Mollema SA, Atary JZ, et al. Time course of global left ventricular strain after acute myocardial infarction. *Eur Heart J* 2010;31:2006-13.
[PUBMED](#) | [CROSSREF](#)
8. Hung CL, Verma A, Uno H, et al. Longitudinal and circumferential strain rate, left ventricular remodeling, and prognosis after myocardial infarction. *J Am Coll Cardiol* 2010;56:1812-22.
[PUBMED](#) | [CROSSREF](#)
9. Ersbøll M, Valeur N, Mogensen UM, et al. Prediction of all-cause mortality and heart failure admissions from global left ventricular longitudinal strain in patients with acute myocardial infarction and preserved left ventricular ejection fraction. *J Am Coll Cardiol* 2013;61:2365-73.
[PUBMED](#) | [CROSSREF](#)
10. Cha MJ, Kim HS, Kim SH, Park JH, Cho GY. Prognostic power of global 2D strain according to left ventricular ejection fraction in patients with ST elevation myocardial infarction. *PLoS One* 2017;12:e0174160.
[PUBMED](#) | [CROSSREF](#)
11. Antoni ML, Mollema SA, Delgado V, et al. Prognostic importance of strain and strain rate after acute myocardial infarction. *Eur Heart J* 2010;31:1640-7.
[PUBMED](#) | [CROSSREF](#)
12. Wang N, Hung CL, Shin SH, et al. Regional cardiac dysfunction and outcome in patients with left ventricular dysfunction, heart failure, or both after myocardial infarction. *Eur Heart J* 2016;37:466-72.
[PUBMED](#) | [CROSSREF](#)
13. Kalam K, Otahal P, Marwick TH. Prognostic implications of global LV dysfunction: a systematic review and meta-analysis of global longitudinal strain and ejection fraction. *Heart* 2014;100:1673-80.
[PUBMED](#) | [CROSSREF](#)
14. Seo Y, Ishizu T, Aonuma K. Current status of 3-dimensional speckle tracking echocardiography: a review from our experiences. *J Cardiovasc Ultrasound* 2014;22:49-57.
[PUBMED](#) | [CROSSREF](#)
15. Muraru D, Niero A, Rodriguez-Zanella H, Cherata D, Badano L. Three-dimensional speckle-tracking echocardiography: benefits and limitations of integrating myocardial mechanics with three-dimensional imaging. *Cardiovasc Diagn Ther* 2018;8:101-17.
[PUBMED](#) | [CROSSREF](#)
16. Maffessanti F, Nesser HJ, Weinert L, et al. Quantitative evaluation of regional left ventricular function using three-dimensional speckle tracking echocardiography in patients with and without heart disease. *Am J Cardiol* 2009;104:1755-62.
[PUBMED](#) | [CROSSREF](#)
17. Truong VT, Phan HT, Pham KN, et al. Normal ranges of left ventricular strain by three-dimensional speckle-tracking echocardiography in adults: a systematic review and meta-analysis. *J Am Soc Echocardiogr* 2019;32:1586-1597.e5.
[PUBMED](#) | [CROSSREF](#)
18. Gayat E, Ahmad H, Weinert L, Lang RM, Mor-Avi V. Reproducibility and inter-vendor variability of left ventricular deformation measurements by three-dimensional speckle-tracking echocardiography. *J Am Soc Echocardiogr* 2011;24:878-85.
[PUBMED](#) | [CROSSREF](#)
19. Badano LP, Cucchini U, Muraru D, Al Nono O, Sarais C, Iliceto S. Use of three-dimensional speckle tracking to assess left ventricular myocardial mechanics: inter-vendor consistency and reproducibility of strain measurements. *Eur Heart J Cardiovasc Imaging* 2013;14:285-93.
[PUBMED](#) | [CROSSREF](#)
20. Mutluer FO, Bowen DJ, van Grootel RW, Roos-Hesselink JW, Van den Bosch AE. Left ventricular strain values using 3D speckle-tracking echocardiography in healthy adults aged 20 to 72 years. *Int J Cardiovasc Imaging* 2021;37:1189-201.
[PUBMED](#) | [CROSSREF](#)
21. Dogdus M, Yildirim A, Kucukosmanoglu M, Kilic S, Yavuzgil O, Nalbantgil S. Are there any subclinical myocardial dysfunctions in subjects with aortic valve sclerosis? A 3D-speckle tracking echocardiography study. *Int J Cardiovasc Imaging* 2021;37:207-13.
[PUBMED](#) | [CROSSREF](#)

22. Dogdus M, Simsek E, Cinar CS. 3D-speckle tracking echocardiography for assessment of coronary artery disease severity in stable angina pectoris. *Echocardiography* 2019;36:320-7.
[PUBMED](#) | [CROSSREF](#)
23. Negishi K, Negishi T, Agler DA, Plana JC, Marwick TH. Role of temporal resolution in selection of the appropriate strain technique for evaluation of subclinical myocardial dysfunction. *Echocardiography* 2012;29:334-9.
[PUBMED](#) | [CROSSREF](#)