Comparison of Feasibility, Accuracy, and Reproducibility of Layer-Specific Global Longitudinal Strain Measurements Among Five Different Vendors: A Report from the EACVI-ASE Strain Standardization Task Force

Serkan Ünlü, MD, Oana Mirea, MD, PhD, Jürgen Duchenne, MSc, Efstathios D. Pagourelias, MD, PhD, Stéphanie Bézy, MSc, James D. Thomas, MD, PhD, Luigi P. Badano, MD, PhD, and Jens-Uwe Voigt, MD, PhD, *Leuven, Belgium; Chicago, Illinois; and Padua, Italy*

Background: Despite standardization efforts, vendors still use information from different myocardial layers to calculate global longitudinal strain (GLS). Little is known about potential advantages or disadvantages of using these different layers in clinical practice. The authors therefore investigated the reproducibility and accuracy of GLS measurements from different myocardial layers.

Methods: Sixty-three subjects were prospectively enrolled, in whom the intervendor bias and test-retest variability of endocardial GLS (E-GLS) and midwall GLS (M-GLS) were calculated, using software packages from five vendors that allow layer-specific GLS calculation (GE, Hitachi, Siemens, Toshiba, and TomTec). The impact of tracking quality and the interdependence of strain values from different layers were assessed by comparing test-retest errors between layers.

Results: For both E-GLS and M-GLS, significant bias was found among vendors. Relative test-retest variability of E-GLS values differed significantly among vendors, whereas M-GLS showed no significant difference (range, 5.4%–9.5% [$P = .032$] and 7.0%–11.2% [$P = .200$], respectively). Within-vendor test-retest variability was similar between E-GLS and M-GLS for all but one vendor. Absolute test-retest errors were highly correlated between E-GLS and M-GLS for all vendors.

Conclusions: E-GLS and M-GLS measurements showed no relevant differences in robustness among vendors, although intervendor bias was higher for M-GLS compared with E-GLS. These data provide no technical argument in favor of a certain myocardial layer for global left ventricular functional assessment. Currently, the choice of which layer to use should therefore be based on the available clinical evidence in the literature. (J Am Soc Echocardiogr 2017;■:■-■.)

Keywords: Intervendor, Layer-specific, Reproducibility, Speckle, Strain, Tracking

From the Department of Cardiovascular Diseases, University Hospitals Leuven, Leuven, Belgium (S.U., O.M., J.D., E.D.P., S.B., J.-U.V.); the Bluhm Cardiovascular Institute, Northwestern University, Chicago, Illinois (J.D.T.); and Cardiac, Thoracic and Vascular Sciences, University Padua, Padua, Italy (L.P.B.).

On behalf of the EACVI-ASE-Industry Standardization Task Force, chaired by Luigi P. Badano, Padua, Italy (EACVI); James D. Thomas, Chicago, Illinois (ASE); and the participating companies: Jamie Hamilton (Epsilon), Stefano Pedri (Esaote), Peter Lysyansky (GE), Gunnar Hansen (GE), Yasuhiro Ito (Hitachi), Tomoaki Chono (Hitachi), Jane Vogel (Philips), David Prater (Philips), Joo Hyun Song (Samsung), Jin Yong Lee (Samsung), Helene Houle (Siemens), Bogdan Georgescu (Siemens), Rolf Baumann (TomTec), Bernhard Mumm (TomTec), Yashuhiko Abe (Toshiba), and Willem Gorissen (Toshiba).

Dr. Ünlü is affiliated with the Gazi University Institute of Health Sciences, Department of Pharmacology, Ankara, Turkey; and Atatürk Chest Diseases and Chest Surgery Education and Research Hospital, Ankara, Turkey. Dr. Mirea is currently affiliated with the Department of Cardiology, University of Medicine and Pharmacy, Craiova, Romania. Dr. Pagourelias is currently affiliated with the Third Cardiology Department, Hippokrateion University Hospital, Medical School, Aristotle University of Thessaloniki, Thessaloniki, Greece.

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Reprint requests: Jens-Uwe Voigt, MD, PhD, Department of Cardiovascular Diseases, University Hospitals Leuven, Herestraat 49, 3000 Leuven, Belgium (E-mail: *jens-uwe.voigt@uzleuven.be*).

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Abbreviations

EF = Ejection fraction

E-GLS = Endocardial global longitudinal strain

GLS = Global longitudinal strain

LV = Left ventricular

M-GLS = Midwall global longitudinal strain

The assessment of left ventricular (LV) global function is one of the key tasks of clinical routine echocardiography.[1] In recent years, global longitudinal strain (GLS) has emerged as a new quantitative parameter for this purpose[2] that has been shown to provide complementary and potentially more reproducible information on LV function compared with ejection fraction (EF).[3-5] In its consensus paper,[3] the European Association of Cardiovascular Imaging/American Society of Echocardiography/Industry Task Force to Standardize Deformation Imaging proposed definitions for the acquisition and nomenclature of strain measurements. This proposal has been widely adopted, but controversy remains about the region within the myocardium where longitudinal strain should be measured.[3,6] Although several vendors prefer tracking in the endocardial layer of the myocardium and reporting endocardial strain, the most evidence exists for tracking the full wall thickness and reporting midwall strain.[7] So far, little is known about how strain measurements from different myocardial layers differ among vendors and if there is any reason to favor a certain myocardial layer over another for clinical use.

In this study we sought (1) to assess the intervendor bias of GLS measurements obtained from different myocardial layers and (2) to compare the test-retest variability of GLS measurements from different myocardial layers among vendors in a clinical setting to provide evidence for future discussions within the European Association of Cardiovascular Imaging/American Society of Echocardiography/Industry Task Force to Standardize Deformation Imaging and to provide guidance for the appropriate use of GLS in clinical practice.

METHODS

Study Population

The study was based on data from the second Inter-Vendor Comparison Study.[8] Patients were prospectively recruited from the echocardiography laboratory of the University Hospitals Leuven. The main inclusion criteria were age > 18 years, ability to give consent, ability to walk and to lie in a supine position for 2 hours, a good echocardiographic imaging window, and regular heart rhythm. All patients had histories of myocardial infarction. Healthy volunteers without histories, signs, or symptoms of cardiac pathology and good echocardiographic imaging windows were recruited as stand-by subjects in case planned patients did not show up. The study was approved by the ethics commission of the University Hospitals Leuven, and all subjects gave written informed consent before inclusion.

Industry Partner Recruitment

All major vendors of echocardiography equipment and speckle-tracking analysis software were invited to participate in the study. Five vendors participated with speckle-tracking software that allowed layer-specific GLS analysis (Table 1). All vendors provided dedicated training on their software.

Table 1 Vendors with software capable of layer-specific strain analysis participating in the study

Vendor	Ultrasound machine	Type	Software and version
GE	Vivid E9	High end	EchoPAC 201
Hitachi	Prosound f75	High end	2DTT Analysis 7.0a
Siemens	Acuson S2000 CV system	High end	Syngo VVI 4.0
Toshiba	Artida	High end	ACP 3.2
TomTec*			2D CPA 1.3

*Software-only vendor.

Study Protocol

The study protocol has been previously published.[8] In brief, 63 participants were scanned during nine sessions over 5 days. Each participant was scanned by the same sonographer on all machines. An application specialist from each company was available to ensure optimal settings for image acquisition intended for later speckle-tracking analysis. Patients were examined in the left lateral decubitus position. Two sets of standard apical views in a test-retest scenario and Doppler traces from aortic and mitral valve for cardiac event timing were acquired. A minimum of three consecutive cycles were recorded per view. All image data were stored as raw data in a proprietary company format if available. In addition, all data were also stored in standard Digital Imaging and Communications in Medicine format at the original frame rate to allow postprocessing with the independent software packages.

Data Analysis

EF was calculated using the modified Simpson rule, by obtaining end-diastolic and end-systolic LV volumes from apical four- and two-chamber views. GLS was measured in both the endocardial (E-GLS) and the midwall (M-GLS) layers using software from the five vendors that provide both measurement options (GE, Hitachi, Siemens, Toshiba and TomTec; see Table 1 for details). In the following text, for better readability, only the vendors' names are used to refer to specific software. Digital Imaging and Communications in Medicine images from GE were used for strain analysis with TomTec software. End-diastole was defined by positioning the electrocardiographic trigger point on peak of the R wave. Time of aortic valve closure was measured from pulsed-wave Doppler acquisitions of the LV outflow tract. A region of interest was drawn by delineating endocardial and epicardial contours of the left ventricle to cover the entire myocardium and to obtain layer-specific strain values. In scarred and thin segments, particular care was taken that the region of interest did not exceed the actual wall contours. Endocardial and midwall strain measurement results were accepted as provided by the respective software, as we had no means to verify if the vendors' layer definitions adhere to the recommendations of this task force. Segmental speckle-tracking quality was evaluated comparing the motion of the tracking points with the motion of the underlying myocardium. If all segments in an apical view could be tracked, tracking quality was defined as optimal. In case of four or five segments, tracking quality was noted as acceptable. Apical views with more than two badly tracked segments were rejected from global strain analysis. Peak systolic longitudinal strain was determined for both midmyocardium and endocardium per apical view. GLS was calculated as the average of longitudinal strain values obtained from at least two apical views.