Viewpoint

Left Ventricular Strain: Guideline Update and New Analysis Software

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Introduction

Myocardial strain analysis is a sensitive method for the early assessment of alterations in left ventricular (LV) mechanics; it is capable of detecting incipient changes and is less influenced by ventricular geometry or loading conditions.[1] Echocardiography is a reproducible and cost-effective method for this assessment, given the ongoing development and widespread integration of new technologies into ultrasound systems. Various studies have demonstrated the importance of measuring global longitudinal strain (GLS), in addition to conventional parameters, for assessment of structural and functional changes in diverse clinical scenarios,[1] including the following:

- Athletes
- Systemic arterial hypertension
- Cardiomyopathies (dilated, ischemic, Chagas, cardiotoxicity, amyloidosis, Fabry, hypertrophic, takotsubo)
- Active ischemic heart disease
- Arrhythmias
- Dyssynchrony
- Valvular heart diseases

Myocardial segment for strain analysis and standardization of echocardiographic reporting

Ultrasound software vendors currently vary regarding the optimal myocardial segment (endocardium, myocardium, or epicardium) for strain analysis.[2] Although endocardial tracking, combined endocardial and epicardial analysis, and midwall/full-wall tracking are equally feasible and reproducible, there is growing evidence that midwall strain measurements based on full-wall tracking are less susceptible to variations in imaging geometry that are considered suboptimal.[1,3] There is also more robust evidence in the literature regarding reference values and clinical applicability for this approach, which also appears to be the most accurate, as the region of interest (ROI) includes a larger number of myocardial points (speckles) that can be tracked[1,2] (Figure 1).

Keywords

Sprains and Strains; Heart Ventricles; Echocardiography

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Regarding standardization of echocardiographic reporting, the American Society of Echocardiography (ASE) and the European Association of Cardiovascular Imaging (EACVI), in their latest consensus statement,[1] recommend the following:

1. When presenting segmental strain values, the negative sign should be retained for differentiating dyskinetic from normal myocardial contractility.

2. If the negative sign is omitted, then the term global longitudinal shortening should be used to correctly refer to the values presented.

3. The current recommendation is to report the myocardial strain value determined at the end of ventricular systole, rather than the peak systolic value[1,2] (maximum negative systolic strain within the systolic interval or peak strain), as illustrated in Figure 2.

4. Reference values for LV GLS are as follows[1,5]:

   Normal: More negative than −18%

   Borderline: −16% to −18%

   Abnormal: Less negative than −16%.*

   * Morris et al. conducted the most comprehensive meta-analysis on LV GLS, involving a total of 47 studies and 23,208 healthy adults.[5] This study identified 16% (absolute value) as the lower limit of normal across major software packages.

5. Normal values of GLS may vary between software versions. Comparisons of GLS should ideally be made using the same software vendor and version.[1]

6. The optimal use of LV GLS is in sequential follow-up, by comparison with baseline. A relative change of 10% to 15% is likely significant.[1]

7. The use of three-dimensional strain is still in development due to variations in software and inconsistent results, and it is not recommended for clinical use.[1]

8. Regional strain values have shown too much variability between tests and between vendors to be used clinically.[1]

Determining the timing of the systolic period

Accurate determination of the effective systolic period is fundamental for myocardial strain quantification.[1,4] Echocardiographic assessment, as validated in ultrasound systems, commonly employs the following time markers:

- **End-diastole:** Peak of the R wave on the electrocardiogram.
- **End-systole:** End of the T wave on the electrocardiogram or aortic valve closure in the apical three-chamber view.

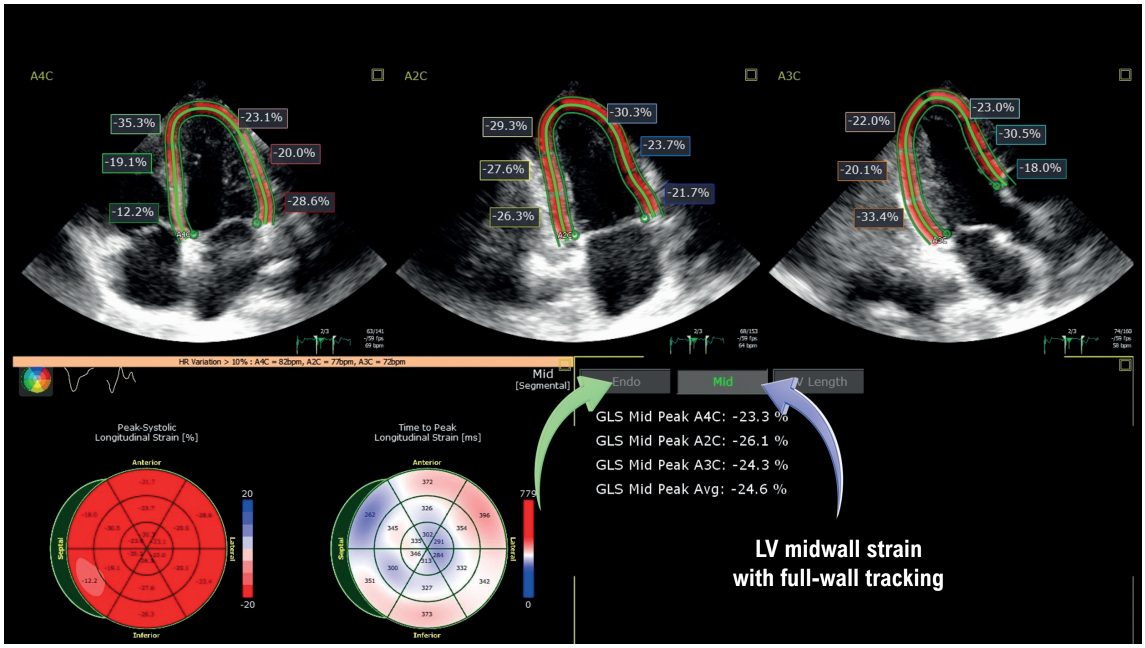

Figure 1 – *Assessment recommended by the ASE and the EACVI[1] regarding the myocardial segment tracked for the analysis of LV GLS, as well as the description of the final value (blue arrow). Despite the recommendation to use the midwall segment of the left ventricle, echocardiography software still allows assessment of other segments, such as, in this case, the endocardial segment (green arrow). LV: left ventricular.*

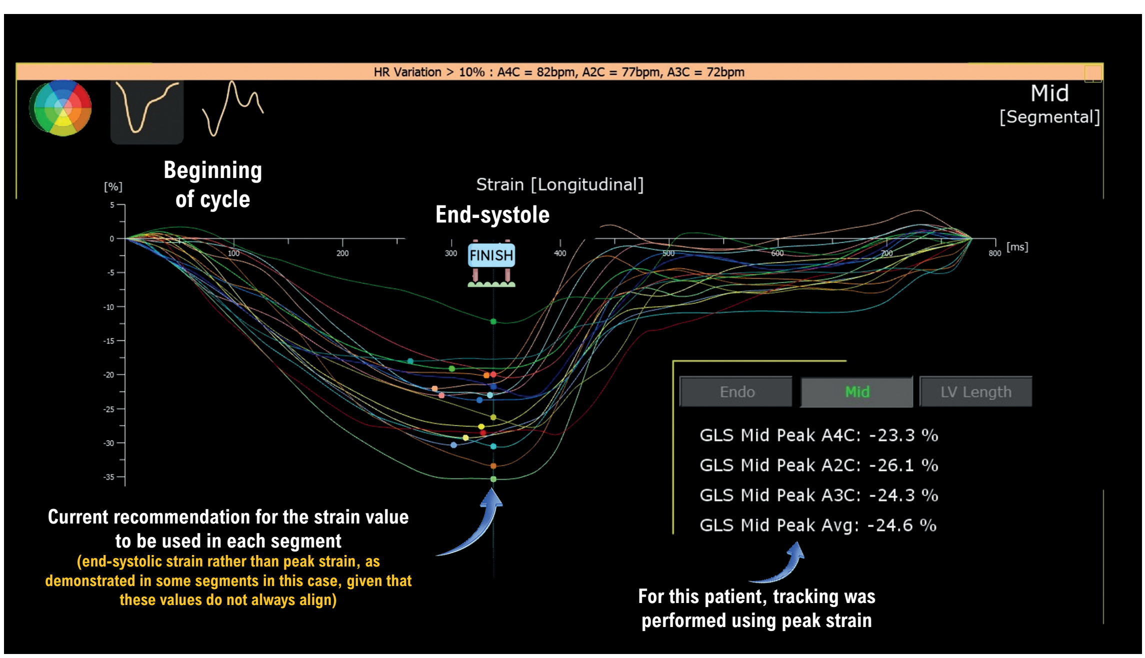

Figure 2 – *Assessment of strain curves and description of the values to be used. According to the Clinical Applications of Strain Echocardiography: A Clinical Consensus Statement from the ASE Developed in Collaboration with the EACVI of the European Society of Cardiology, the final value used should be the one shown at the end of ventricular systole, which does not always align with peak strain.[1,4]*

This assessment can be replaced by event markers guided exclusively by two-dimensional echocardiography:

- **End-diastole:** Mitral valve closure or the onset of a new cardiac cycle.[1,4]
- **End-systole:** Aortic valve closure.[1,4]

Precautions and implications of errors during analysis

Image analysis for strain estimation is based on the following assumptions:

- The image was adequately acquired and is of sufficient quality to allow for effective speckle tracking.
- The region under analysis was correctly defined.
- Systolic and diastolic timings were accurately identified.

Inaccuracy in any of these factors can lead to errors in the strain results. Listed below are the main factors that can increase or decrease strain values:[1]

– Parameters that may overestimate strain values:
  - Image acquisition with LV foreshortening[3]
  - Narrow ROI
  - Inaccurate definition of end-diastolic and end-systolic timing[4]
  - Using only a single cardiac cycle in cases of arrhythmia, for example, atrial fibrillation

– Parameters that may underestimate strain values:
  - Inadequate image quality (incorrect speckle tracking)
  - Wide ROI
  - Inaccurate definition of end-diastolic and end-systolic timing
  - Using only a single cardiac cycle in cases of arrhythmia, for example, atrial fibrillation

Limitations and new technological solutions

Despite the validated standardization for myocardial strain assessment, the significant volume of echocardiographic exams in outpatient settings often means that electrocardiography is not routinely used; this hinders the retrospective analysis of cardiac strain and the determination of global strain values.

Considering these data, some companies have incorporated features into their software that allow for strain assessment without electrocardiographic gating, as well as using data from a single cardiac cycle, thereby facilitating assessment of results either during the exam or afterward. For this analysis, it is necessary to determine the end-diastolic point between two cardiac cycles, as shown in Figure 3.

In previous software for analysis, it was important to mark the timing of both mitral valve closure and aortic valve closure. However, in current analysis methods, these data points are replaced by a cardiac cycle gated exclusively by mitral valve opening and closure using M-mode (superior temporal resolution). Figure 4 outlines the step-by-step process for acquiring data and analyzing GLS without requiring an electrocardiogram.

Conclusion

Gating images for strain analysis using the mitral valve leaflet is a viable, reliable, and easily reproducible alternative that is increasingly being incorporated into the software embedded in echocardiography systems. Given the impact of this analysis across various clinical scenarios, this alternative should always be considered; it greatly facilitates the reporting of this echocardiographic parameter, which has validated prognostic value superior to that of ejection fraction alone. As with any new analysis technique, this approach requires comparative studies to determine the accuracy of the measurement in relation to established, validated markers of clinical events.

Author Contributions

Conception and design of the research and writing of the manuscript: Gomes HM; Silva HAGP.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

This article does not contain any studies with human participants or animals performed by any of the authors.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Availability of Research Data

The contents underlying the research text are already available in a data repository, under the following DOIs:

10.1093/ehjci/jeag006

10.1016/j.echo.2014.11.003

10.1093/ehjci/jez189

10.1016/j.jcmg.2014.10.010

10.1016/j.jcmg.2024.11.004

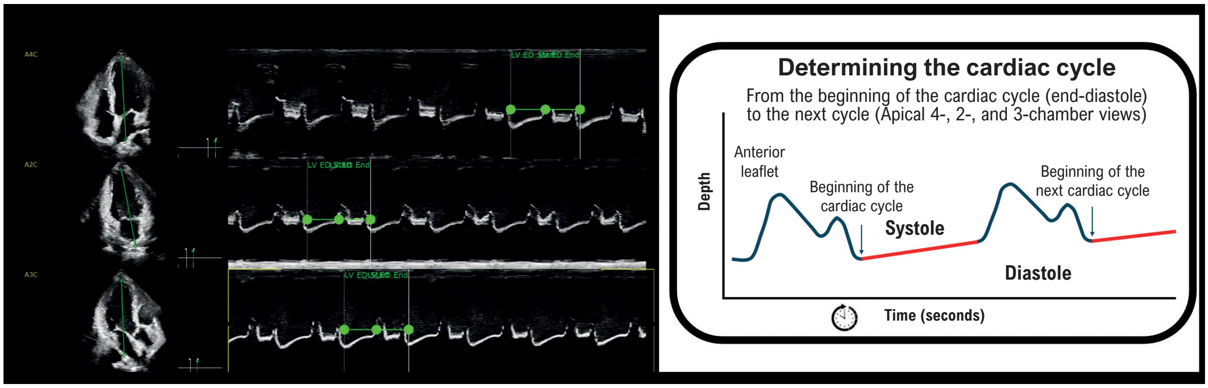

Figure 3 – *M-mode assessment of the mitral valve (anterior leaflet) to accurately establish cardiac cycle timing. Markers must first identify end-diastole, which guides the speckle-tracking software in determining the beginning and end of the cardiac cycle (in this case, tracking a single complete cardiac cycle).*

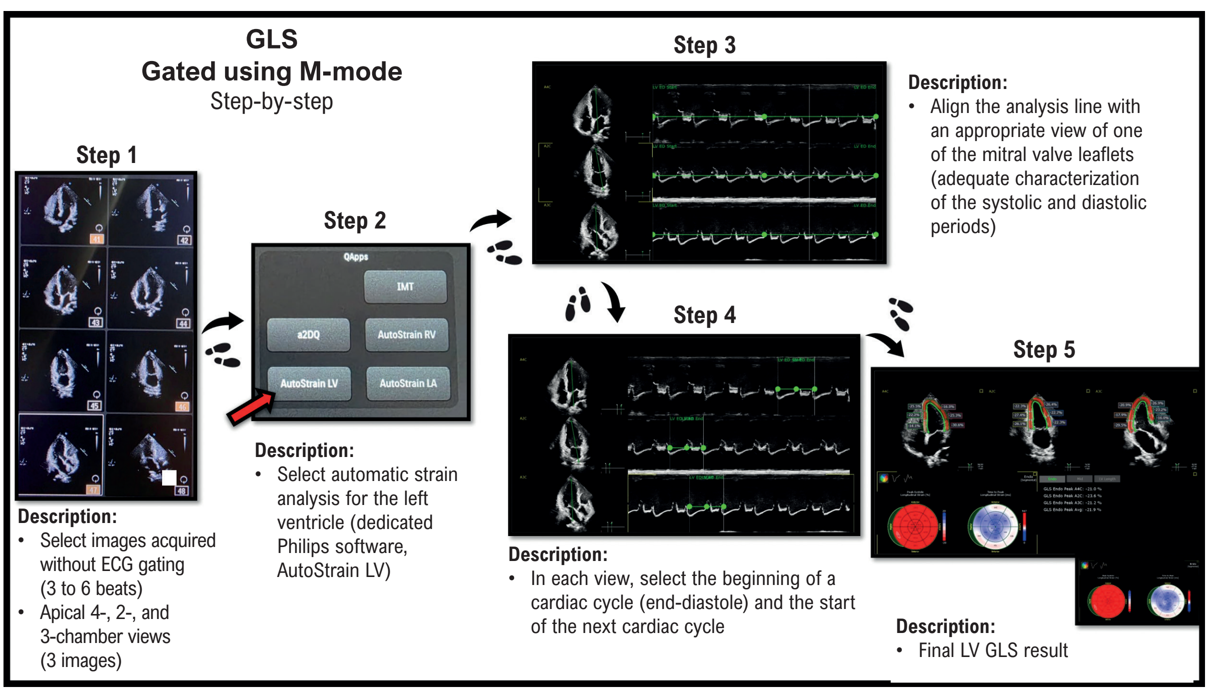

Figure 4 – *Step 1: Acquisition of echocardiographic images in the 4-chamber, 2-chamber, and 3-chamber views (3 to 6 cycles whenever possible). Step 2: Select the images and initiate automatic strain analysis using dedicated software, in this case, AutoStrain LV. Step 3: Using M-mode, select a view through the mitral valve (anterior or posterior leaflet) to allow for correct tracking of the cardiac cycle. Generally, the anterior leaflet allows for better tracking due to its length. Step 4: Manually determine the end-diastolic period (start of the cycle) by marking this parameter in two cardiac cycles (Note: If necessary, adjust ROI thickness, depending on myocardial thickness, and use moving two-dimensional imaging to better identify end-diastole). Step 5: Accept the tracking and longitudinal strain result, and record the global value in the report. GLS: global longitudinal strain; LV: left ventricular.*

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