

How I Assess Left Ventricular Systolic Function

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Abstract

Assessment of left ventricular systolic function is central to transthoracic echocardiography and remains essential in clinical practice and research. Although left ventricular ejection fraction is still the most widely used parameter, advances in echocardiographic techniques have broadened diagnostic assessment. This review summarizes key methods for evaluating systolic function, from traditional linear measurements to modern two- and three-dimensional volumetric approaches. The roles and limitations of the Simpson method, contrast echocardiography, three-dimensional imaging, myocardial deformation analysis, and artificial intelligence are discussed, emphasizing the importance of an integrated and individualized approach.

My Approach to the Echocardiographic Assessment of Left Ventricular Systolic Function

Assessment of Left Ventricular (LV) systolic function is a cornerstone of transthoracic echocardiography and is essential in both clinical practice and cardiovascular research. Left Ventricular Ejection Fraction (LVEF) is widely used for risk stratification, diagnosis, and follow-up of conditions such as heart failure, valvular heart disease, cardiomyopathies, and chemotherapy-related cardiotoxicity.¹⁻³ Although cardiac magnetic resonance imaging is the gold standard for volumetric quantification, echocardiography is more accessible, noninvasive, low-cost, and applicable in multiple clinical settings. Technological advances and artificial intelligence algorithms have increased accuracy, reproducibility, and the early detection of functional abnormalities,⁴ strengthening echocardiography as a first-line imaging modality. Here, we review the main echocardiographic methods used to analyze LV systolic function, with emphasis on practical applications and limitations. Historically, the Teichholz formula, described in the 1970s, estimated ventricular volumes using M-mode or two-dimensional (2D) diameter measurements. Although groundbreaking at the time, it relied heavily on rigid geometric assumptions and is valid only for normal hearts and situations in which high precision is not required. Diameters

are measured in the parasternal long-axis view at the level of the chordae tendineae, at end-diastole (LVEDD) and end-systole (LVESD), following guideline recommendations.⁵ Small deviations in the ultrasound beam can lead to errors, making standardization essential. This method is no longer routinely used in the United States and Europe, but it still appears in some practices in Brazil, especially in high-volume settings and in patients without structural heart disease. Beginning in the 1990s, the biplane Simpson's method, also known as the modified biplane method of disks, became the reference technique for quantifying ventricular volumes and LVEF.⁵ This method reconstructs the LV geometry using images from apical four- and two-chamber views, with adequate endocardial definition. At end-diastole (the largest cavity, identified at the onset of the QRS complex) and end-systole (the smallest cavity), the endocardial border is manually or semi-automatically traced, excluding papillary muscles and trabeculations, which are considered part of the cavity. The software divides the ventricle into multiple thin cylindrical disks to calculate end-diastolic and end-systolic volumes, from which LVEF is automatically derived (Figure 1). The primary technical requirement is to avoid LV foreshortening by ensuring truly orthogonal apical views, preventing volume underestimation. We use this method routinely in patients with regional wall-motion abnormalities, LV dysfunction, and in cases in which clinical decisions depend on precise LVEF quantification, such as in heart failure, cardiomyopathies, valvular heart disease, and selection for cardiac resynchronization therapy.⁶ For patients requiring greater accuracy, even when the heart appears structurally normal, such as those receiving or about to receive cardiotoxic chemotherapy, the Simpson method remains the technique of choice. In this context, when available, Three-dimensional (3D) echocardiography is preferred because it reduces variability in volume and EF measurements, which is essential when rigorous monitoring is needed.⁷ Some limitations of the biplane method, however, must be acknowledged: its accuracy depends strongly on acoustic window quality; therefore, in cases with suboptimal images, we use Ultrasound Contrast Agents (UCA), microbubbles of gas encapsulated by lipid, protein, or polymer shells and administered intravenously.⁸ These microbubbles act as strong acoustic scatterers, increasing signal intensity and improving endocardial border delineation, which allows for more accurate volume and LVEF measurements (Figure 2). It is important to emphasize that UCAs should be reserved for situations with a clear clinical need for enhanced endocardial definition or volumetric quantification, considering their additional costs and potential adverse effects. When the Simpson method cannot be applied due to a limited acoustic window, and UCAs are not available, LVEF may be estimated visually, integrating apical and parasternal views. Visual

Keywords

Echocardiography; Left Ventricular Function; Heart Rate

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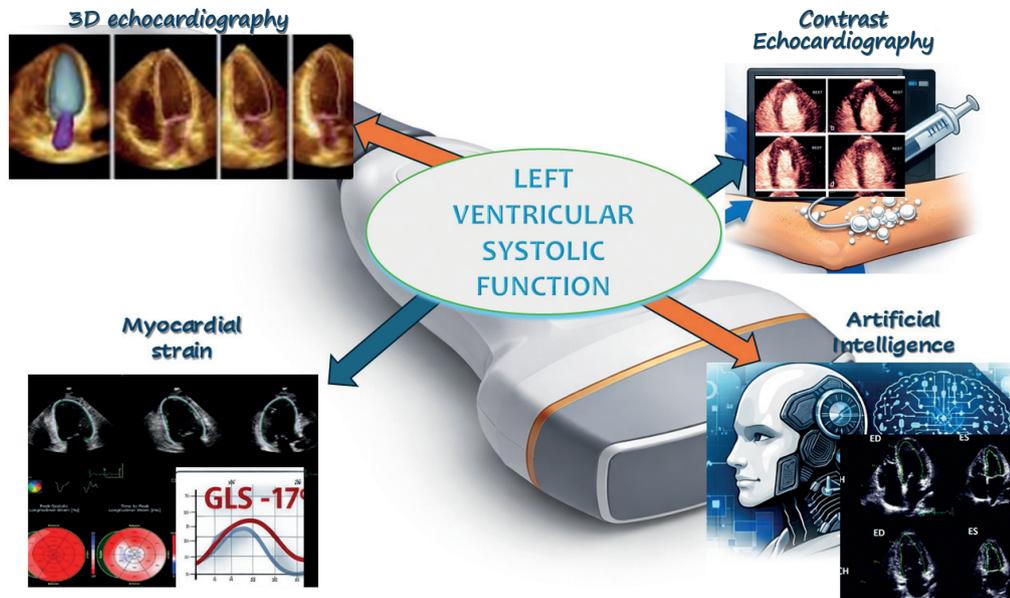
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Central Illustration: How I Assess Left Ventricular Systolic Function



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estimation is widely used in clinical practice and even in major clinical trials in which volumetric quantification was not feasible.⁹ Another limitation of the Simpson method is the presence of localized contraction abnormalities in the anteroseptal or inferolateral walls. In these cases, when feasible, 3D echocardiography should be prioritized. This technique allows full-volume LV acquisition from multiple planes, eliminating geometric assumptions and providing precise cavity reconstructions (Figure 3). Image quality may still limit adequate volume acquisition, particularly in patients with poor acoustic windows, although recent advances in software and image acquisition have improved processing speed and reliability. Additionally, 3D echocardiography reduces interobserver variability and improves accuracy in volume and EF assessment, making it particularly useful in patients with significant ventricular remodeling.¹⁰ Although inter- and intraobserver variability is lower with the biplane method than with linear measurements, it may still occur, especially in studies with limited technical quality. Finally, compared with cardiac MRI, the Simpson method tends to underestimate absolute volumes, although it maintains good correlation for LVEF. For this reason, 3D echocardiography is generally preferred for more precise volume estimation.¹¹ Regarding myocardial deformation imaging with two-dimensional speckle tracking, in my practice, I incorporate this analysis whenever LV impairment is suspected but not fully characterized by conventional 2D echocardiography (Figure 4). This includes cases such as unexplained increases in myocardial thickness, use of potentially cardiotoxic drugs,¹² or subtle signs of ventricular dysfunction. For such, we use apical two-, three-, and four-chamber images

with adequate endocardial definition, manually or semi-automatically tracing endocardial borders at end-diastole and end-systole to calculate Global Longitudinal Strain (GLS), aiming to acquire at least two consecutive cardiac cycles to reduce variability. Despite being dependent on image quality, GLS is highly sensitive and reproducible, especially with new automated software, and provides a reliable complementary assessment of LV systolic function [1,2]. The need for extensive technical training has become less relevant due to recent technological advances. More recently, artificial intelligence (AI) tools have been incorporated into echocardiographic practice, with algorithms capable of automating 2D, 3D, and strain analyses. These systems enhance standardization, reduce analysis time, and allow the detection of subtle patterns imperceptible to conventional techniques, increasing efficiency and reproducibility. I have used these software tools for cardiac diameter measurement, 2D and 3D volume calculation, and strain assessment;^{13,14} however, manual adjustments are still necessary to ensure measurement accuracy. As these technologies continue to evolve, a substantial portion of repetitive echocardiographic tasks will become automated, reducing manual workload.¹⁵ Thus, my current approach to evaluating LV systolic function combines traditional methods with advanced technologies, applied critically and individualized to each patient's clinical context.

Author Contributions

Conception and design of the research: Rodrigues ACT. Writing of the manuscript: Rodrigues ACT. Critical revision of the manuscript for intellectual content: Rodrigues ACT.

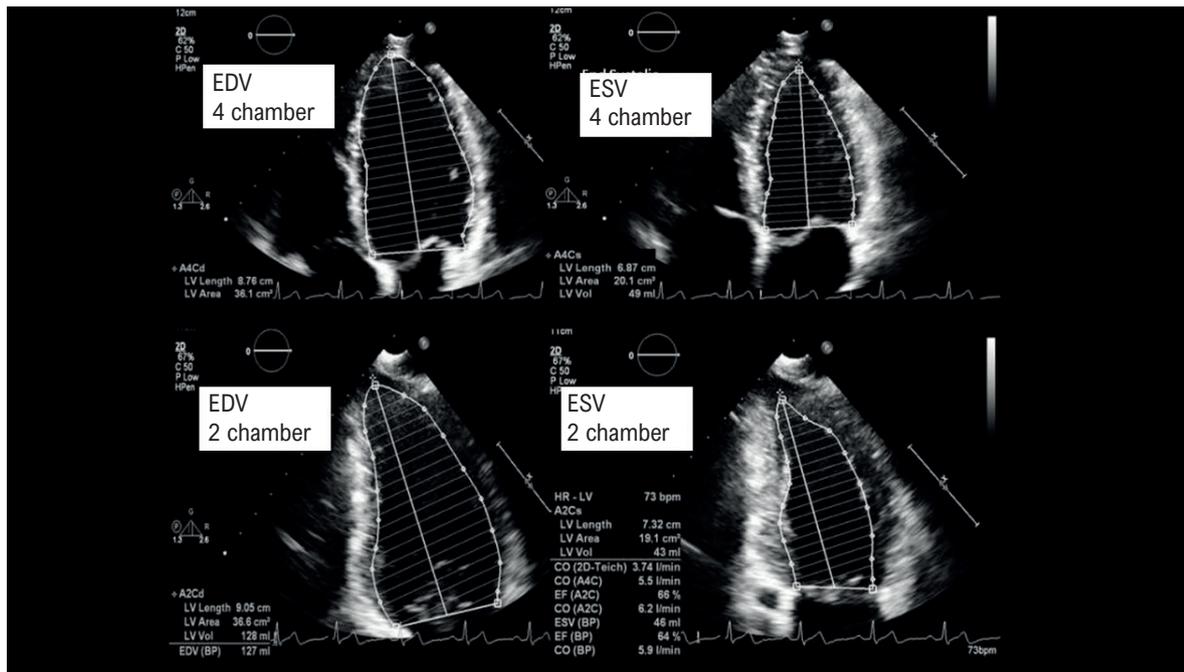


Figure 1 – Apical 2- and 4-chamber images used to obtain LV volumes and ejection fraction using the biplane Simpson method. EDV: End Diastolic Volume; ESV: End Systolic Volume.

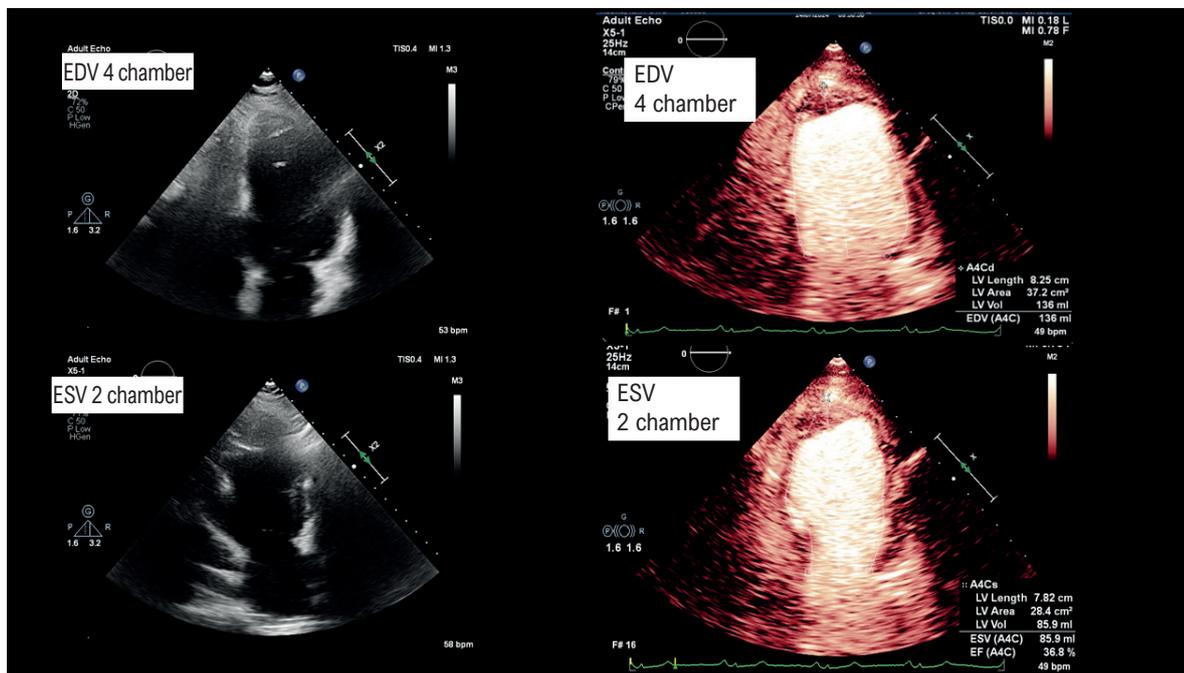


Figure 2 – Apical 4- and 2-chamber images with limited quality. After administration of the ultrasound contrast agent, there is improved endocardial visualization, enabling accurate delineation and reliable biplane measurements. A mural apical thrombus is also visible. EDV: End Diastolic Volume; ESV: End Systolic Volume.

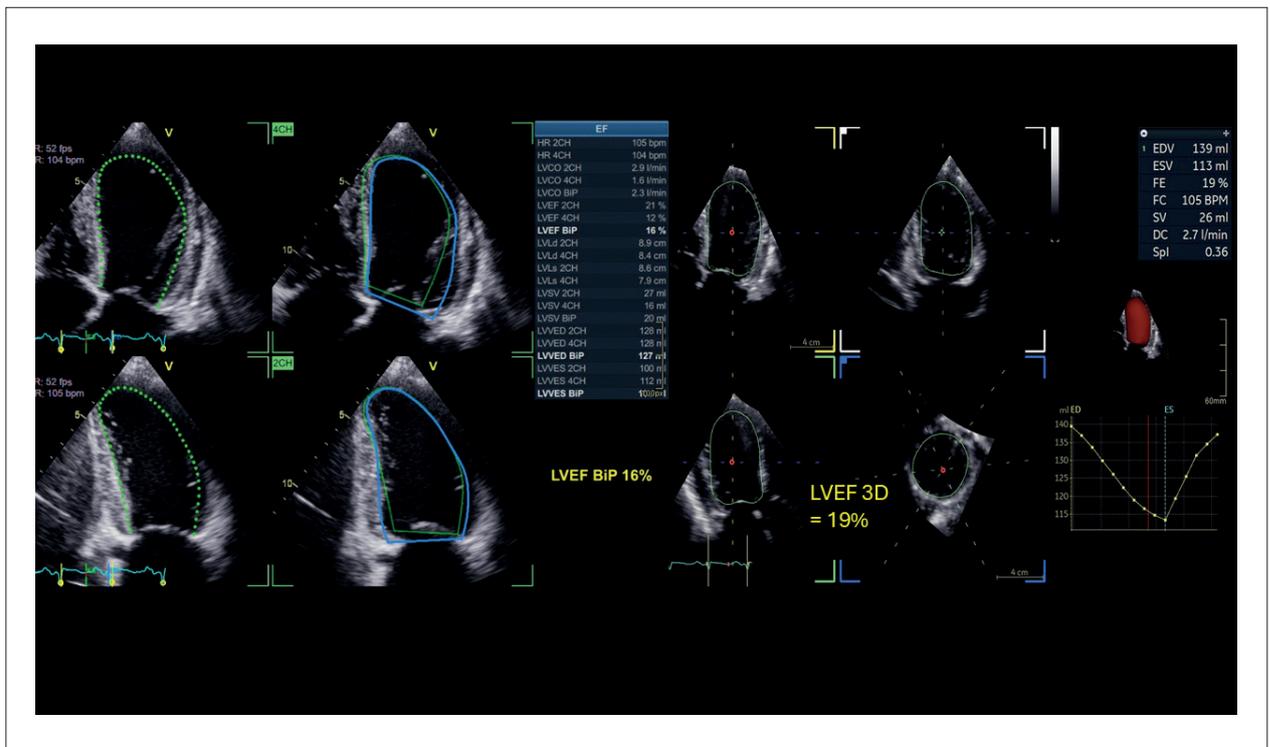


Figure 3 – Two- and three-dimensional images with LVEF measurements in a patient with peripartum cardiomyopathy and significant systolic dysfunction. Measurements were obtained semi-automatically.

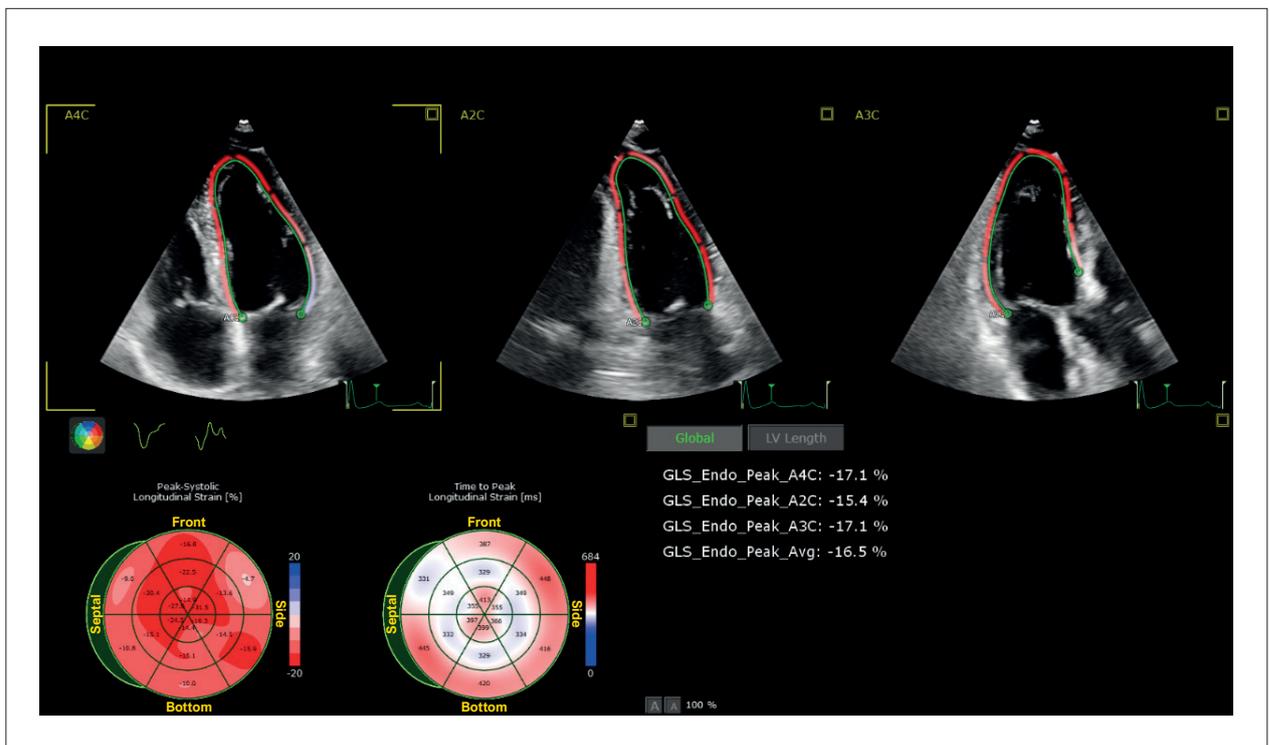


Figure 4 – Two-dimensional speckle-tracking strain analysis in a patient with suspected hemochromatosis. LVEF was preserved, but GLS was reduced, especially in basal LV segments.

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 underlying content of the research text is contained within the manuscript.

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