

Concordance Between Echocardiographic Left Ventricular Ejection Fraction by Simpson's Method, Global Longitudinal Strain, and Cardiac Magnetic Resonance

Álvaro Herrera-Escandón,^{1,2} Juan Pablo Morales-Grisales,¹ Sebastián Ayala-Zapata,¹ Stephany Barbosa-Balaguera,³ Álvaro José Muriel-Ruiz,¹ Juan Felipe Bravo-Rueda,² José Eduardo Citelli-Ramírez,^{1,2} Luis Fernando Osío-Jimenez,² Luis Miguel Benitez-Gómez,² Carlos Javier Ramírez-Estupiñán²

Universidad del Valle, Departamento de Medicina Interna, Sección de Cardiología,¹ Cali – Colombia

Clínica Imbanaco, Servicio de Cardiología,² Cali – Colombia

Clínica Colsanitas S.A., Clínica Sebastián de Belalcázar, Servicio de Cardiología,³ Cali – Colombia

Abstract

Background: Left ventricular ejection fraction (LVEF) measured by echocardiography is a widely used parameter in clinical practice for the assessment of ventricular function. More recently, global longitudinal strain (GLS) has emerged as a complementary method, as has the assessment of LVEF by cardiac magnetic resonance (CMR). However, regional evidence evaluating the concordance among these three techniques remains limited.

Objectives: To assess the concordance between echocardiographic and CMR measurements in patients treated at a cardiovascular clinic in the city of Cali, Colombia.

Methods: This cross-sectional, analytical, descriptive study included 35 patients with confirmed or suspected heart disease, in whom all three methods were performed consecutively. Concordance was evaluated using Lin's concordance correlation coefficient (CCC), Bland-Altman plots for LVEF, and linear and quadratic weighted κ coefficients for agreement between LVEF classifications.

Results: The mean age was 58 years, and 60% of participants were male. The most common comorbidities were hypertension (22%) and dyslipidemia (11%). The mean LVEF was 59% by Simpson's method and 57.7% by CMR, while the mean GLS was -17.7% . Concordance was as follows: Simpson's LVEF vs. CMR (CCC, 0.831; 95%CI, 0.609-0.932); GLS vs. CMR-derived LVEF (CCC, 0.751; 95%CI, 0.419-0.903); and Simpson's LVEF vs. GLS (CCC, 0.891; 95%CI, 0.721-0.957).

Conclusions: Both Simpson's method and GLS are valid tools for estimating systolic function. CMR remains the reference standard.

Keywords: Stroke Volume; Echocardiography; Magnetic Resonance Spectroscopy.

Introduction

Left ventricular ejection fraction (LVEF) is the principal parameter of systolic function and one of the most widely used metrics in clinical practice. It serves as a key prognostic marker in heart failure, myocardial infarction, valvular disease, and in the risk stratification of multiple cardiovascular conditions.¹ Throughout the history of medicine, a number of approaches have been used to quantify systolic function, ranging from heart rate and pulse pressure to conventional radiography and nuclear imaging techniques. Notably, LVEF

reflects ventricular ejection (stroke volume) rather than directly measuring myocardial contractility.² Traditionally, LVEF is quantified using 2D echocardiography with the biplane Simpson's method, which has demonstrated broad clinical utility despite inherent limitations, including operator dependence, variability in acoustic window quality, and reliance on geometric assumptions.³

In recent years, the assessment of ventricular function using speckle-tracking echocardiography (STE), particularly global longitudinal strain (GLS), has emerged as a robust and complementary technique for evaluating global left ventricle (LV) function, with greater sensitivity for detecting subclinical dysfunction. In addition to providing independent prognostic information, GLS shows strong correlations with LVEF and with parameters derived from reference imaging modalities such as cardiac magnetic resonance (CMR).³

CMR is considered the reference standard for the assessment of ventricular volumes, mass, and function due to its high accuracy and reproducibility. However, its high

Mailing Address: Stephany Barbosa Balaguera •

Universidad del Valle. Calle 13 # 100-00. Postal code: 760042. Cali – Colombia

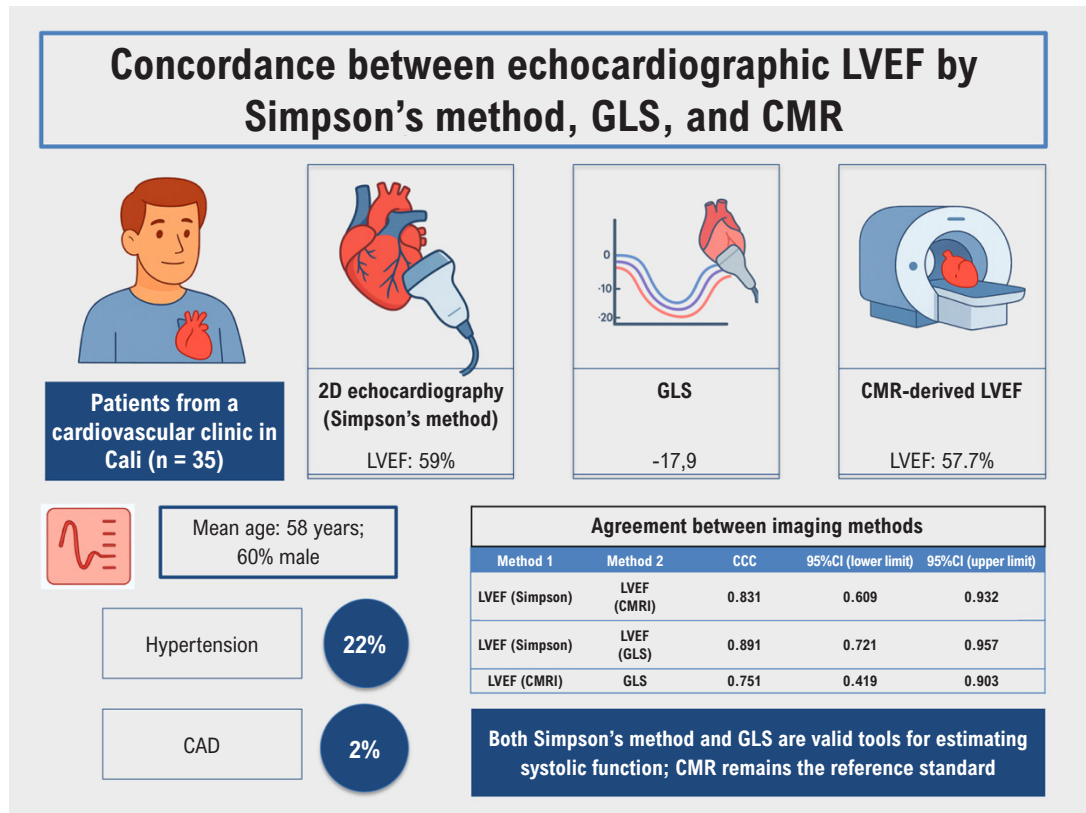
E-mail: sb.balaguera@hotmail.com

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Central Illustration: Concordance Between Echocardiographic Left Ventricular Ejection Fraction by Simpson's Method, Global Longitudinal Strain, and Cardiac Magnetic Resonance



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Concordance Between Echocardiographic Left Ventricular Ejection Fraction by Simpson's Method, Global Longitudinal Strain, and Cardiac Magnetic Resonance CAD: coronary artery disease; CCC: Lin's concordance correlation coefficient; CMR: cardiac magnetic resonance; GLS: global longitudinal strain; LVEF: left ventricular ejection fraction.

cost, limited availability, and restricted accessibility in middle-income countries limit its routine use. Consequently, validating echocardiographic methods against CMR within local clinical settings is essential, particularly given that echocardiography remains the cornerstone of cardiovascular diagnosis.¹

In Colombia, cardiovascular centers have progressively incorporated advanced imaging techniques. However, regional evidence evaluating the concordance between Simpson-derived LVEF, ventricular strain parameters, and CMR-derived LVEF remains limited. Generating local data may improve diagnostic accuracy and support more effective therapeutic decision-making in patients with prevalent cardiovascular diseases.

Therefore, the present study aims to evaluate the agreement between echocardiographic LVEF obtained using the biplane Simpson method and automated volumetric analysis, and CMR-derived LVEF. Additionally, the study explores the relationship between GLS measurements and CMR-based assessment of systolic function in patients treated at a cardiovascular clinic in the city of Cali, Colombia.

Methods

Study design and population

A descriptive, analytical, cross-sectional study was conducted, including 35 patients referred for CMR for morphological assessment. Each patient also underwent a comprehensive transthoracic echocardiographic examination, including strain analysis and the determination of ventricular volumes and ejection fraction, performed within the same evaluation period.

Because of the exploratory nature of this study, the sample size was determined by convenience and included all consecutive patients who met the inclusion criteria and had complete echocardiographic and CMR data available within the predefined time frame.

The study population comprised patients aged ≥ 18 years with a confirmed diagnosis or suspected heart disease, who underwent both a complete echocardiogram and CMR within a 24-hour interval, with all required data available for analysis.

Clinical and demographic assessment

A demographic and clinical evaluation was performed, including patient characteristics, indications for imaging, and final diagnostic outcomes.

Echocardiographic assessment

Echocardiographic analyses were conducted in the echocardiography laboratory of a level IV cardiovascular clinic by cardiologists specialized in echocardiography. Imaging was performed using Philips EPIQ and Affiniti 70C systems and analyzed using the TomTec platform.

Images were acquired in three standard apical views (two-, three-, and four-chamber) to enable reconstruction of the 17-segment LV model. GLS was obtained by using 2D STE following automated endocardial border detection, with manual adjustments when necessary. GLS was calculated as the average peak systolic longitudinal strain across all 17 LV segments.

LV end-diastolic and end-systolic volumes were automatically calculated by the software based on endocardial border delineation from the apical views. LVEF was subsequently derived from these volumetric measurements according to standard echocardiographic principles. Although GLS and volumetric LVEF were obtained during the same acquisition, they represent independent measurements of myocardial deformation and ventricular volume.

The echocardiographic operator was blinded to the CMR results. Additional variables from the final echocardiographic report were also recorded.

CMR

CMR-derived strain analysis was not performed. During the study period, feature-tracking CMR strain analysis was not routinely available at our institution and therefore could not be systematically incorporated into the study protocol.

Statistical analysis

Statistical analyses were performed using RStudio version 2025.09.2+418. The normality of continuous variables was assessed using the Shapiro-Wilk test. Normally distributed variables are presented as mean \pm standard deviation, whereas non-normally distributed variables are reported as median and interquartile range. Categorical variables are expressed as absolute and relative frequencies.

Agreement between LVEF measurements obtained by different imaging modalities was evaluated using Lin's concordance correlation coefficient (CCC) and Bland-Altman analysis for continuous values. Agreement between categorical classifications of LVEF severity was assessed using linear and quadratic weighted κ coefficients.

All concordance estimates are reported with 95% CIs, and a two-sided p-value < 0.05 was considered statistically significant.

Results

A total of 35 patients were included in the clinical, echocardiographic, and CMR analyses. Table 1 summarizes the demographic characteristics of the study population, the main cardiovascular conditions, and relevant paraclinical findings. Figure 1 presents the clinical indications for CMR, with dilated cardiomyopathy being the most frequent indication (29%).

Table 1 – Characteristics of the study population

Demographic and clinical data	
Variables	Value
Age, years (IQR)	58 (41-62.5)
Male sex, n (%)	21 (60.0)
Hypertension, n (%)	8 (22.9)
T2DM, n (%)	2 (5.7)
Dyslipidemia, n (%)	4 (11.4)
Smoking history, n (%)	3 (8.6)
Significant CAD, n (%)	1 (2.9)
MINOCA, n (%)	1 (2.9)
Myocarditis, n (%)	3 (8.6)
Laboratory data	
Variables	Value
Troponin, pg/mL (IQR)	0.44 (0.13-36.12)
NT-proBNP, pg/mL (IQR)	4,371 (362-5,717)

CAD: coronary artery disease; IQR: interquartile range; MINOCA: myocardial infarction with non-obstructive coronary arteries; NT-proBNP: N-terminal pro-B-type natriuretic peptide; T2DM: type 2 diabetes mellitus.

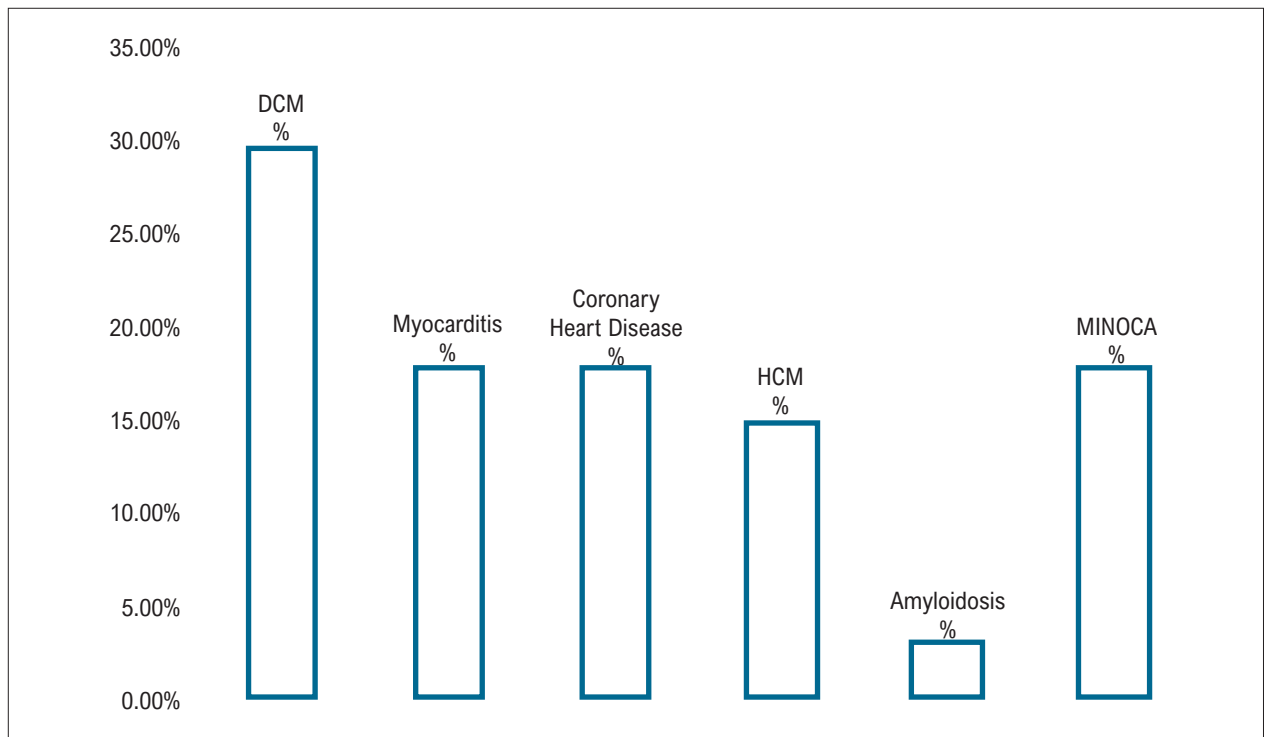


Figure 1 – Distribution of clinical indications for CMR in the study population. CHD: coronary heart disease; DCM: dilated cardiomyopathy; HCM: hypertrophic cardiomyopathy; MINOCA: myocardial infarction with non-obstructive coronary arteries.

Table 2 summarizes the overall echocardiographic findings. The mean interventricular septal and inferoposterior wall thicknesses were 10.1 mm and 9.6 mm, respectively. Table 2 also reports the mean and median values of key echocardiographic parameters, including ventricular dimensions in systole and diastole, as well as indices of diastolic function. In addition, the average systolic function assessed by each method evaluated in this study is presented.

In the analysis of agreement for continuous values, substantial concordance was observed among the three methods. The highest concordance was found between Simpson-derived LVEF and GLS (Table 3). Bland-Altman analysis demonstrated no evidence of systematic bias between methods. The comparison between Simpson-derived LVEF and CMR showed a minimal mean difference (MD) with acceptable limits of agreement. Similarly, GLS showed no clinically relevant systematic overestimation or underestimation when compared with CMR (Graph 1; Graph 2; Graph 3).

Regarding the categorical classification of systolic function severity, agreement was good across all comparisons (Table 4).

Central Illustration summarizes the key findings of the study.

Discussion

The assessment of LVEF remains one of the most widely used approaches for evaluating systolic function in clinical practice. Despite its central role in diagnosis and therapeutic decision-making across multiple cardiovascular conditions, the available techniques for measuring LVEF have inherent limitations that may reduce sensitivity and reproducibility.⁴

CMR is the most accurate method for measuring LVEF and is therefore considered the reference standard for comparison with other imaging modalities. Previous studies have shown that 3D echocardiography demonstrates the lowest bias when compared with CMR.^{2,4} In contrast, 2D echocardiographic methods have been associated with variability of up to $\pm 15\%$ relative to CMR and have been shown to misclassify approximately 9.3% of patients with cardiotoxicity identified by CMR. In the MATCH study, differences exceeding 10% between 2D and 3D LVEF measurements were observed when compared with CMR, with variability influenced by female sex and body mass index $> 35 \text{ kg/m}^2$.⁵

In the search for methods with lower variability, myocardial strain has emerged as a robust tool for evaluating global LV function. Strain imaging has demonstrated clinical utility in the detection of subclinical dysfunction in heart failure, cardiomyopathies, valvular disease, and chemotherapy-related cardiotoxicity.^{6,7} GLS also provides independent prognostic information, including mortality risk, even in cases where LVEF has limited discriminatory capacity.

In the present study, agreement among the three noninvasive methods for assessing systolic function (Simpson biplane LVEF, GLS, and CMR-derived LVEF) was good, both for continuous values and for categorical classification. According to the criteria proposed by Altman et al.,⁸ the concordance between Simpson-derived LVEF and GLS (CCC, 0.891), as well as between Simpson-derived LVEF and CMR (CCC, 0.831), can be considered excellent (> 0.8). In contrast, the agreement between GLS and CMR-derived LVEF (CCC, 0.751), although slightly lower, still represents good concordance.

Table 2 – Echocardiographic, strain-derived, and CMR data

Variables	Value
Echocardiographic measurements	
LVEF by Simpson, %	59 (50-61)
LV end-diastolic volume, mL	107 (42-245)
LV end-systolic volume, mL	57 (18-185)
LV end-diastolic diameter, mm	49 (37-74)
LV end-systolic diameter, mm	34 (24-65)
Septal wall thickness, mm	10 (9-10)
Posterior wall thickness, mm	
Indexed LA volume, mL/m ²	43 (19-111)
E/A ratio	1.2 (0.9-1.5)
E/e' ratio	9 (6-17)
TAPSE, mm	22.4 ± 3.0
Segmental wall-motion abnormalities, n (%)	12 (34.3)
Strain-derived measurements	
GLS, %	−17.9 (−20.4 a −15.0)
LVEF (2D STE automated volumetric analysis), %	58.8 (21.1-73.6)
LV end-diastolic volume, mL	90.5 (53-245)
LV end-systolic volume, mL	44.8 (14-193)
CMR measurements	
LVEF by CMR, %	57.7 (47-65)
LV end-diastolic volume, mL	151.5 (89-421)
LV end-systolic volume, mL	63 (29-320)
LGE, n (%)	7 (20.0)
Myocardial edema (T2), n (%)	3 (8.6)
Pericardial effusion, n (%)	3 (8.6)

CMR: cardiac magnetic resonance; GLS: global longitudinal strain; LA: left atrium; LGE: late gadolinium enhancement; LV: left ventricle; LVEF: left ventricular ejection fraction; STE: speckle-tracking echocardiography; TAPSE: tricuspid annular plane systolic excursion.

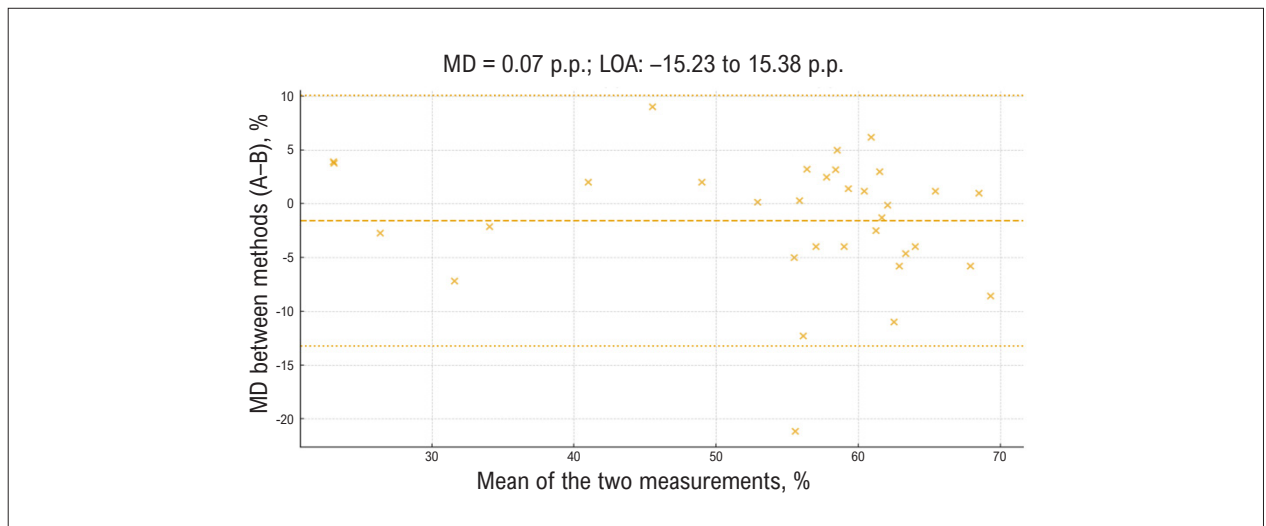
Table 3 – Agreement between imaging methods

Method 1	Method 2	CCC	95%CI (lower limit)	95%CI (upper limit)
LVEF (Simpson)	LVEF (CMR)	0.831	0.609	0.932
LVEF (Simpson)	LVEF (GLS-derived)	0.891	0.721	0.957
LVEF (CMR)	GLS	0.751	0.419	0.903

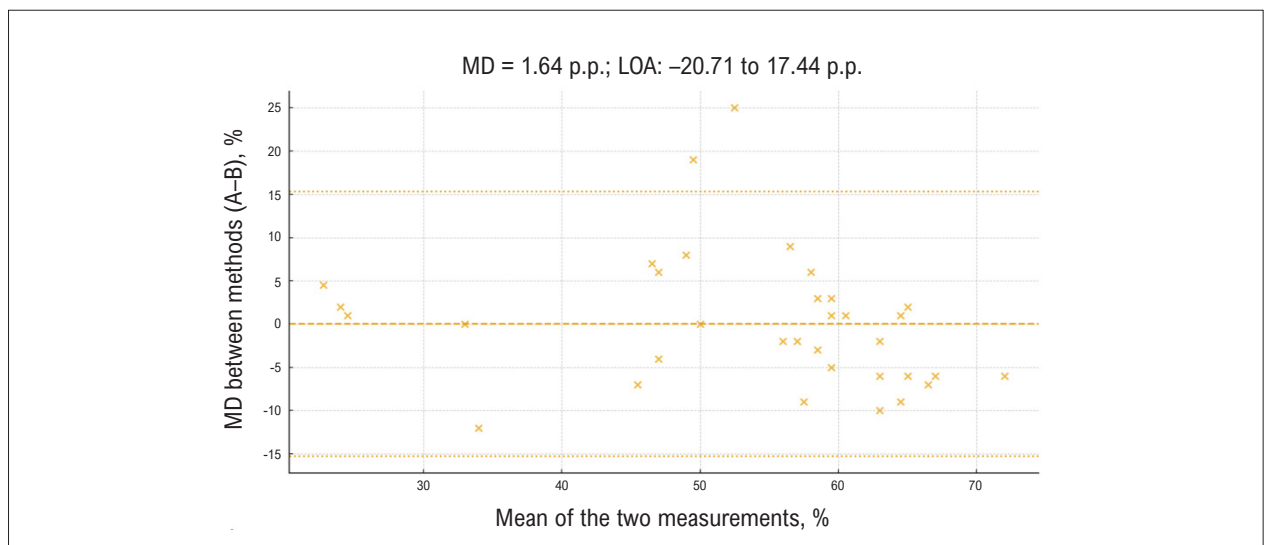
CCC: Lin's concordance correlation coefficient; CMR: cardiac magnetic resonance; GLS: global longitudinal strain; LVEF: left ventricular ejection fraction.

Bland-Altman analysis further supports these findings. The comparison between Simpson-derived LVEF and CMR demonstrated a minimal MD (−0.07), suggesting near equivalence, albeit with relatively wide limits of agreement, reflecting interindividual variability. In contrast, GLS tended

to slightly underestimate LVEF compared with CMR (MD, −1.64), with even wider limits of agreement. These findings suggest that, although GLS may underestimate LVEF relative to CMR, it maintains a strong relationship with conventional 2D measurements, supporting its role



Graph 1 – MD between LVEF measured by Simpson’s method and CMR-derived LVEF. CMR: cardiac magnetic resonance; MD: mean difference; LOA: limits of agreement; LVEF: left ventricular ejection fraction.



Graph 2 – MD between GLS-derived LVEF (2D STE automated volumetric analysis) and CMR-derived LVEF. CMR: cardiac magnetic resonance; GLS: global longitudinal strain; LOA: limits of agreement; LVEF: left ventricular ejection fraction; MD: mean difference; STE: speckle-tracking echocardiography.

as a complementary parameter rather than a substitute for volumetric assessment.

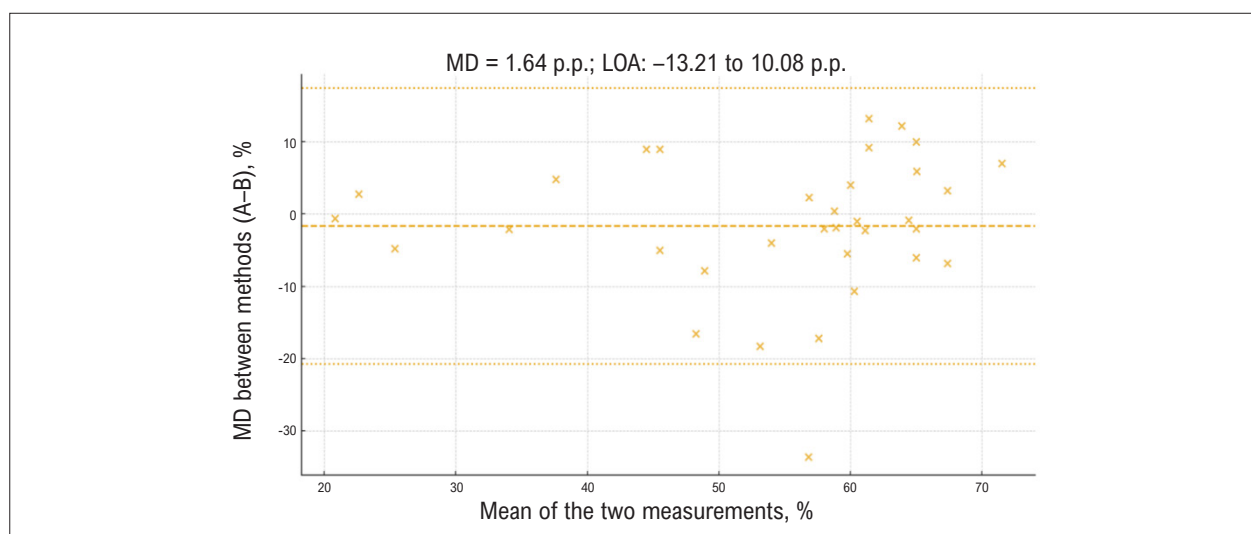
From a clinical perspective, where categorical LVEF thresholds guide diagnosis, treatment, and intervention, agreement was nearly perfect when assessed using quadratic weighted κ . Both Simpson-derived LVEF ($\kappa = 0.808$) and GLS-derived classification ($\kappa = 0.862$) showed excellent concordance with CMR, which indicates all three methods allow consistent classification of ventricular dysfunction severity.

Our findings are consistent with previous studies demonstrating good agreement between echocardiographic and CMR-derived LVEF, particularly when standardized acquisition protocols and

high-quality imaging are used. However, the Bland-Altman analysis revealed relatively wide limits of agreement (approximately ± 15 - 20 p.p.), which may be clinically significant at the individual level. Such variability is particularly relevant when LVEF thresholds are used to guide therapeutic decisions, including eligibility for device therapy or initiation of specific pharmacological treatments. These observations reinforce the importance of interpreting LVEF within a broader clinical and imaging context rather than in isolation.

Study limitations

This study has several limitations. The relatively small sample size reduces statistical power and increases uncertainty



Graph 3 – MD between LVEF measured by Simpson’s method and GLS-derived LVEF (2D STE automated volumetric analysis). GLS: global longitudinal strain; LOA: limits of agreement; LVEF: left ventricular ejection fraction; MD: mean difference; STE: speckle-tracking echocardiography.

Table 4 – Agreement between methods for categorical classification of LVEF

A) Simpson vs CMR					
LVEF (Simpson)	Normal	Mild	Moderate	Severe	Total
Normal	21	1	1	0	23
Mild	3	4	0	0	7
Moderate	0	0	1	0	1
Severe	0	0	1	3	4
Total	24	5	3	3	35
Quadratic weighted κ : 0.808 95%CI: 0.743-0.874					
B) GLS vs CMR					
LVEF (GLS-derived)	Normal	Mild	Moderate	Severe	Total
Normal	23	2	1	0	26
Mild	1	2	0	0	3
Moderate	0	1	2	0	3
Severe	0	0	0	3	3
Total	24	5	3	3	35
Quadratic weighted κ : 0.862 95%CI: 0.812-0.912					

CMR: cardiac magnetic resonance; GLS: global longitudinal strain; LVEF: left ventricular ejection fraction.

around concordance estimates, as reflected in the width of confidence intervals. In addition, the single-center design may limit external validity and generalizability. Therefore, the results should be interpreted as exploratory and hypothesis-generating. Larger, prospective, multicenter studies are needed

to confirm the reproducibility and external applicability of these findings.

Another important limitation is the clinical heterogeneity of the study population, which included patients with diverse cardiovascular conditions. Variations in myocardial geometry,

regional wall-motion abnormalities, and tissue characteristics may influence agreement between echocardiographic and CMR measurements and may partly explain the observed variability.

Furthermore, 3D echocardiography was not included in this study. Given that 3D echocardiography has been shown to improve agreement with CMR-derived ventricular volumes and LVEF, future studies incorporating this modality may provide additional insight into the interchangeability of noninvasive imaging techniques.

Overall, these findings indicate that both Simpson's method and GLS are valid tools for estimating systolic function. GLS represents a promising complementary parameter, particularly useful for detecting subclinical dysfunction and subtle longitudinal changes. However, it should not replace volumetric assessment of LVEF. While automated volumetric analysis using 2D STE software showed good agreement with Simpson-derived LVEF, volumetric quantification remains essential in clinical scenarios requiring precision. CMR continues to be the reference standard, particularly when accurate quantification or detailed tissue characterization is required.

Conclusions

Both Simpson's method and GLS are valid tools for the assessment of systolic function, whereas CMR remains the reference standard. GLS represents a valuable complementary parameter for evaluating LVEF, particularly for the detection of subtle or subclinical dysfunction; however, it should not be considered a substitute for volumetric LVEF measurement. Further studies are warranted to compare the diagnostic performance of imaging modalities used in clinical practice for the assessment of LV systolic function.

Author Contributions

Conception and design of the research: Herrera-Escandón A, Ayala-Zapata S, Muriel-Ruiz AJ, Citelli-Ramírez JE, Osío-Jimenez LF, Benitez-Gómez LM, Ramírez-Estupiñán CJ; acquisition of data: Herrera-Escandón A, Bravo-Rueda JF,

Citelli-Ramírez JE, Osío-Jimenez LF, Benitez-Gómez LM, Ramírez-Estupiñán CJ; analysis and interpretation of the data: Morales Grisales JP, Barbosa Balaguera S, Muriel-Ruiz AJ, Citelli-Ramírez JE, Osío-Jimenez LF, Ramírez-Estupiñán CJ; statistical analysis: Ayala-Zapata S; writing of the manuscript: Herrera-Escandón A, Morales Grisales JP, Ayala-Zapata S, Barbosa Balaguera S, Muriel-Ruiz AJ, Bravo-Rueda JF, Benitez-Gómez LM, Ramírez-Estupiñán CJ; Critical revision of the manuscript for intellectual content: Herrera-Escandón A, Ayala-Zapata S, Barbosa Balaguera S.

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

During the preparation of this work, the author(s) used ChatGPT to create images included in the Central Illustration. After using this tool/service, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the published article.

Availability of Research Data

All datasets supporting the results of this study are available upon request from the corresponding author.

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