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Cardiac MRI *Versus* Echocardiography for Left Ventricular Ejection Fraction Assessment: a Prospective Comparative Study

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ABSTRACT

Background and objective: *Accurate assessment of left ventricular ejection fraction (LVEF) is fundamental to the diagnosis, risk stratification and management of cardiovascular diseases. Cardiac magnetic resonance imaging (CMR) is the established reference standard, while echocardiography and global longitudinal strain (GLS) provide widely accessible alternatives. This study compared LVEF by CMR, two-dimensional echocardiography (2D Echo), three-dimensional echocardiography (3D Echo) and GLS in patients with cardiovascular diseases at a Northeast Indian tertiary care centre.*

Materials and methods: *A hospital-based prospective observational comparative study enrolled 50 patients with confirmed cardiovascular pathology at Assam Medical College and Hospital (AMCH), Dibrugarh. Cardiac magnetic resonance imaging was performed on a Siemens Magnetom Avanto 1.5 T scanner; echocardiography employed the Philips Affiniti CVx system. Agreement was assessed by Bland-Altman analysis and intraclass correlation coefficient (ICC).*

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Results: *The mean CMR-LVEF was 48.5 ± 12.3%. 2D Echo showed a mean positive bias of +2.7 percentage points (95% limits of agreement [LoA]: −8.5% to +13.9%; ICC 0.89) and 3D Echo showed superior agreement (bias +1.3%; LoA −6.2% to +8.8%; ICC 0.93). Upward reclassification by 2D Echo occurred in 26% of patients. Global longitudinal strain strongly correlated with CMR-LVEF (r = −0.87, p < 0.001) and identified subclinical dysfunction in 35% of patients with preserved LVEF (≥50%).*

Conclusions: *Cardiac magnetic resonance remains the reference standard for LVEF quantification. 3D Echo shows significantly superior agreement with CMR* versus *2D Echo. Global longitudinal strain provides incremental diagnostic value beyond LVEF. A tiered multimodality imaging strategy with selective CMR confirmation at clinical decision boundaries is recommended.*

Keywords: cardiac MRI, echocardiography, left ventricular ejection fraction, global longitudinal strain, cardiovascular diseases, India.

ABBREVIATIONS

CMR: cardiac magnetic resonance
LVEF: left ventricular ejection fraction
GLS: global longitudinal strain
2D Echo: two-dimensional echocardiography
3D Echo: three-dimensional echocardiography
LoA: limits of agreement
ICC: intraclass correlation coefficient
ICD: implantable cardioverter-defibrillator
SD: standard deviation.

INTRODUCTION

Left ventricular ejection fraction (LVEF) remains the single most clinically utilised parameter in the assessment of cardiac systolic function. Accurate LVEF determination governs eligibility for implantable cardioverter-defibrillator (ICD) therapy at the ≤35% threshold, cardiac resynchronisation therapy, initiation of guideline-directed medical therapy for heart failure with reduced ejection fraction (HFrEF), and stratification of chemotherapy cardiotoxicity risk (1).

Cardiac magnetic resonance (CMR) is the internationally recognised reference standard for LV volumetric quantification, offering three-dimensional coverage without geometric assumptions and excellent reproducibility (1). Its limited availability and higher cost are particularly relevant in resource-constrained settings such as Northeast India (2). Two-dimensional echocardiography (2D Echo) employing Simpson's biplane method is the most widely used modality for cardiac functional assessment (3) but relies on a geometric ellipsoidal model that introduces systematic error when ventricular geometry is distorted by ischaemia or cardiomyopathy.

Three-dimensional echocardiography (3D Echo) eliminates these geometric assumptions through direct volumetric acquisition and has demonstrated improved accuracy relative to 2D methods (1, 4). Global longitudinal strain (GLS) by speckle-tracking echocardiography detects subclinical myocardial dysfunction before volumetric indices become abnormal and provides incremental prognostic value (5, 6). Comparative data from Indian tertiary care populations evaluating modality interchangeability and the role of GLS remain limited (2). This study aimed to compare LVEF by CMR, 2D Echo and 3D Echo; evaluate GLS correlations; and quantify clinically relevant reclassification rates across major management thresholds.

Although the relative performance of these modalities has been examined internationally, three considerations define the specific contribution of the present work. Firstly, comparative data from Northeast India – a region in which CMR access is limited and in which the referral pattern and case-mix of cardiovascular disease differ from Western validation cohorts – remain scarce. Secondly, most prior reports compare two modalities at a time; this study evaluates CMR, 2D Echo, 3D Echo and GLS within a single prospectively enrolled cohort, permitting a direct head-to-head appraisal under identical clinical conditions. Thirdly, rather than reporting agreement statistics alone, the analysis quantifies how inter-modality disagreement translates into reclassification across the precise LVEF categories that govern therapy – the ≤35% ICD-eligibility and ≤40% pharmacotherapy thresholds – expressing measurement error in directly actionable terms. Therefore, the intended added value lies not in re-establishing CMR as the reference standard, which is well accepted, but in characterising the magnitude, direction and clinical consequences of echocardiographic misclassification in a real-world Indian tertiary-care population and in delineating where GLS adds information beyond the ejection fraction. ❑

MATERIALS AND METHODS

Study design and setting

A hospital-based prospective observational comparative study was conducted in the Department of Radiodiagnosis, AMCH, Dibrugarh, Assam, India, over one year (September 2024 to September 2025). Ethical clearance was obtained from the Institutional Human Ethics Committee of AMCH. The study was conducted in accordance with the Declaration of Helsinki (2013) and applicable Indian Council of Medical Research guidelines. Written informed consent was obtained from all participants.

Participants

Fifty patients with confirmed cardiovascular pathology referred for CMR were enrolled. Eligibility criteria are detailed in Table 1. The sample size was based on an expected concordance rate derived from the published comparative literature (7), which reported a high concordance between echocardiographic and CMR-derived LVEF. Applying a single-proportion estimation for an expected agreement of approximately 85%, a 95% confidence level and a 15% absolute margin of error, the minimum required sample was 35 patients; 50 subjects were enrolled to provide a margin against incomplete or non-analysable studies and to preserve power within the principal diagnostic subgroups. This cohort size is consistent with comparable single-centre CMR-*versus*-echocardiography validation studies, which have typically enrolled between 20 and 60 patients owing to the cost and limited availability of CMR. The resulting constraints on statistical power, particularly for low-frequency subgroups, are explicitly acknowledged in the Limitations section.

Cardiac magnetic resonance imaging (MRI) protocol

Cardiac magnetic resonance was performed on a Siemens Magnetom Avanto 1.5 Tesla scanner using a dedicated cardiac phased-array coil with prospective ECG gating. SSFP cine sequences were acquired as a contiguous short-axis stack (8 mm slices, 2 mm gap; 20–25 cardiac phases; TR/TE ≈3.0/1.5 ms; flip angle 70°; temporal resolution ≤45 ms). Manual endocardial contouring was performed by a single blinded radiologist using Siemens Argus software; LVEF = (LVEDV − LVESV)/LVEDV × 100%. Intra-observer ICC was 0.97 in a 10-patient reproducibility subset.

Echocardiography protocol

All echocardiographic examinations were performed by experienced cardiologists blinded to CMR results using the Philips Affiniti CVx system with the X5-1 matrix array transducer, in accordance with ASE/EACVI 2015 guidelines (3). 2D LVEF was measured by Simpson's biplane method from apical 4- and 2-chamber views, averaged over

TABLE 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Clinically confirmed cardiovascular pathology referred for CMR	Contraindications to MRI (pacemaker, cochlear implant, non-MRI-safe implants, severe claustrophobia)
All age groups and both sexes	Inability to provide informed consent
CMR and echocardiography within a seven-day window	Haemodynamic instability precluding standard imaging
Written informed consent provided	Incomplete studies or image quality insufficient for analysis
Adequate image quality on both modalities	Atrial fibrillation or significant arrhythmia during 3D acquisition
	Prior cardiac surgery with distorted ventricular anatomy

CMR=cardiac magnetic resonance; MRI=magnetic resonance imaging three beats. 3D LVEF was derived from a full-volume dataset with semi-automated border detection. The GLS was measured by 2D speckle-tracking echocardiography from apical 4-, 2- and 3-chamber cine loops (≥50 fps); GLS was classified as normal (≤−18%), mildly reduced (−15 to −17%), moderately reduced (−10 to −14%), or severely reduced (<−10%) per published consensus thresholds (8, 9). Cardiac magnetic resonance and echocardiography were performed within a pre-specified window of seven days or less, during which no patient underwent revascularisation, device implantation, or alteration of heart-failure pharmacotherapy, so that both examinations reflected the same clinical state. Echocardiographic measurements were standardised by adherence to ASE/EACVI acquisition criteria, averaging over three cardiac cycles, and interpretation by experienced operators blinded to the CMR findings. The GLS was quantified by 2D speckle-tracking on a single vendor platform; because absolute strain values are not interchangeable between vendors and software packages, additionally deriving GLS from 3D Echo or CMR feature-tracking would have introduced method-dependent bias rather than a like-for-like measurement, and was therefore not undertaken in this cohort (see the Limitations section).

Statistical analysis

Data were analysed using SPSS version 26.0 and Microsoft Excel. Statistical significance was defined as $p < 0.05$. Inter-modality agreement was assessed by Bland-Altman analysis and ICC (two-way mixed-effects model, absolute agreement). Paired t-tests, one-way ANOVA with Bonferroni post-hoc correction and Pearson correlation were applied. Reclassification across four prespecified LVEF categories (<30%, 30–39%, 40–49%, ≥50%) was quantified relative to the CMR reference. ❑

RESULTS

Demographic and clinical profile

Fifty patients [31 (62.0%) males and 19 (38.0%) females] were enrolled. The 51–60-year age group constituted the largest proportion (30.0%), consistent with the known epidemiology of cardiovascular disease in Indian tertiary care settings (2). Ischaemic heart disease was the most common diagnosis (34.0%), followed by heart failure (22.0%) and cardiomyopathy (18.0%). Full demographic data are presented in Table 2 and Figure 1.

TABLE 2. Baseline characteristics of the study population (n=50)

Variable	Category	n (N=50)	%
Age group (years)	≤30	4	8.0
	31–40	7	14.0
	41–50	11	22.0
	51–60	15	30.0
	>60	13	26.0
Sex	Male	31	62.0
	Female	19	38.0
Cardiovascular pathology	Ischaemic heart disease	17	34.0
	Heart failure	11	22.0
	Cardiomyopathy	9	18.0
	Valvular heart disease	6	12.0
	Arrhythmias	3	6.0
	Pericardial disease	2	4.0
	Congenital heart defects	1	2.0
	Hypertension	1	2.0
Total		50	100

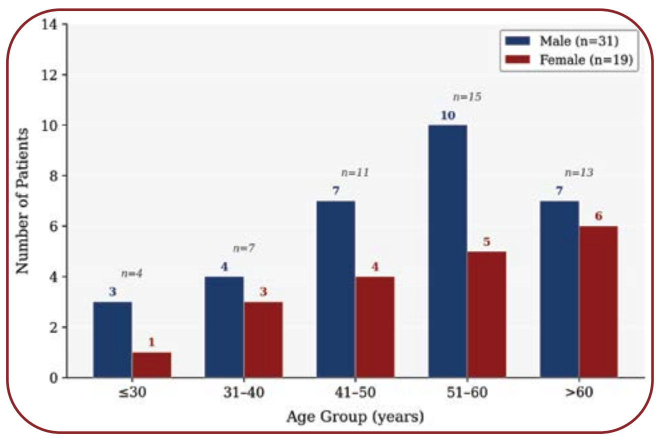

FIGURE 1. Age and sex distribution of the study population (n=50). Grouped bar chart showing the number of male and female patients in each age group. The 51–60-year group constituted the largest proportion (30.0%) and male patients predominated (62.0%). Numbers above each bar indicate individual counts; total *per* age group (n) is shown above the paired bars.

LVEF distribution and mean values

Mean CMR-LVEF was 48.5 ± 12.3% (range 25–68%). 2D Echo yielded a systematically higher mean of 51.2 ± 13.1% (bias +2.7 percentage points), with the proportion classified as preserved LVEF (≥50%) rising from 40.0% to 56.0%. This directional bias reflects the tendency of Simpson's biplane method to overestimate LVEF when ventricular geometry deviates from an ellipsoidal model, most pronounced in ischaemic remodelling and cardiomyopathy (10). 3D Echo closely

TABLE 3. Distribution of cardiovascular risk factors among study participants (n=50)

Cardiovascular risk factor	Number (%)
Hypertension	28 (56.0)
Diabetes mellitus	18 (36.0)
Dyslipidaemia	16 (32.0)
Smoking/tobacco use	14 (28.0)
Alcohol consumption	10 (20.0)
Obesity (body mass index ≥30 kg/m²)	8 (16.0)
Previous coronary artery disease/myocardial infarction	12 (24.0)
Family history of cardiovascular disease	6 (12.0)
Chronic kidney disease	4 (8.0)

Values are presented as frequency (percentage). Multiple risk factors may coexist in the same patient; therefore, percentages do not total 100%.

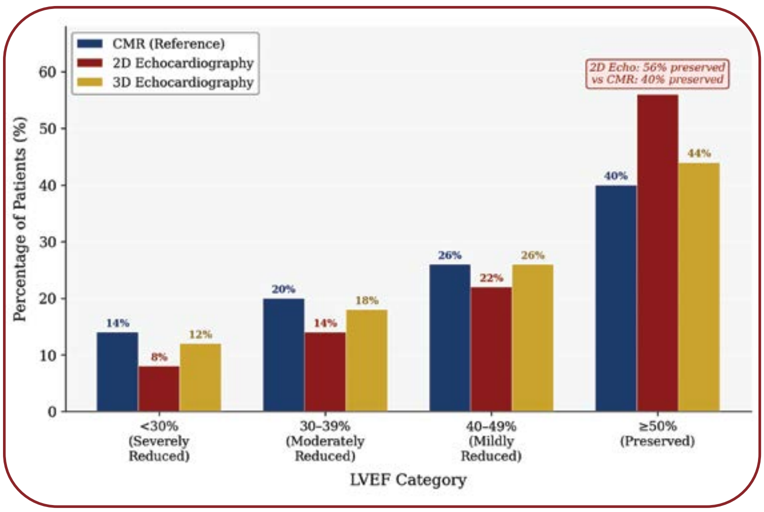

FIGURE 2. LVEF category distribution by imaging modality (n=50). Grouped bar chart comparing the proportion of patients classified into four LVEF categories (<30%, 30–39%, 40–49%, ≥50%) by CMR (reference), 2D echocardiography and 3D echocardiography. 2D echocardiography classified 56.0% of patients as having preserved LVEF (≥50%) compared with 40.0% by CMR, demonstrating a systematic upward shift consistent with Simpson's biplane overestimation at low LVEF values. LVEF: left ventricular ejection fraction; CMR: cardiac magnetic resonance imaging.

approximated CMR (mean 49.8 ± 12.7%; bias +1.3%), reflecting the advantage of volumetric acquisition (1, 4). Distribution and mean values are presented in Tables 4 and 5 and Figure 2.

The cohort carried a high burden of cardiovascular risk factors, the distribution of which is shown in Table 3. Hypertension was the most prevalent (56.0%), followed by diabetes mellitus (36.0%) and dyslipidaemia (32.0%); smoking or tobacco use was recorded in 28.0% of patients. Multiple risk factors frequently coexisted within the same patient, reflecting the high-risk nature of a population referred for advanced multimodality cardiac imaging.

Inter-modality agreement

Bland-Altman analysis for CMR *vs* 2D Echo demonstrated a mean bias of +2.7% with 95% LoA spanning −8.5% to +13.9% (total range 22.4 percentage points), which was identical in magnitude to the overestimation reported by Solyman *et al* (7). For CMR *vs* 3D Echo, the mean bias was +1.3%, with a narrower LoA of −6.2% to +8.8% (range 15.0 pp) (Figure 3). The ICC was 0.89 (good) for CMR *vs* 2D Echo and 0.93 (excellent) for CMR *vs* 3D Echo (1). Representative cases illustrating the relationship between LVEF discordance and the severity of systolic dysfunction are shown in Figure 4: a 47-year-old woman with hypertrophic cardiomyopathy in whom 2D Echo reported a LVEF of 35% (the ICD-eligibility threshold), while CMR demonstrated 28%; a 65-year-old man with restrictive cardiomyopathy showing the largest absolute discordance (2D Echo 63% *versus* CMR 47.6%); and a 58-year-old man with chest pain in whom the two modalities closely agreed (2D Echo 66% *versus* CMR 64.9%). The

TABLE 4. LVEF category distribution by imaging modality (n=50)

LVEF category (%)	CMR – reference n (%)	2D Echo n (%)	3D Echo n (%)
<30	7 (14.0%)	4 (8.0%)	6 (12.0%)
30–39	10 (20.0%)	7 (14.0%)	9 (18.0%)
40–49	13 (26.0%)	11 (22.0%)	13 (26.0%)
≥50	20 (40.0%)	28 (56.0%)	22 (44.0%)
Total	50 (100%)	50 (100%)	50 (100%)

TABLE 5. Summary of mean LVEF values and agreement parameters

Imaging modality	Mean LVEF ± SD (%)	Range (%)	Bias *vs* CMR (%)	ICC *vs* CMR
CMR (reference)	48.5 ± 12.3	25–68	—	—
2D Echocardiography	51.2 ± 13.1	28–72	+2.7	0.89 (good)
3D Echocardiography	49.8 ± 12.7	26–70	+1.3	0.93 (excellent)
GLS (absolute, %)*	14.2 ± 4.5	7–22	r = −0.87	0.87 (good)

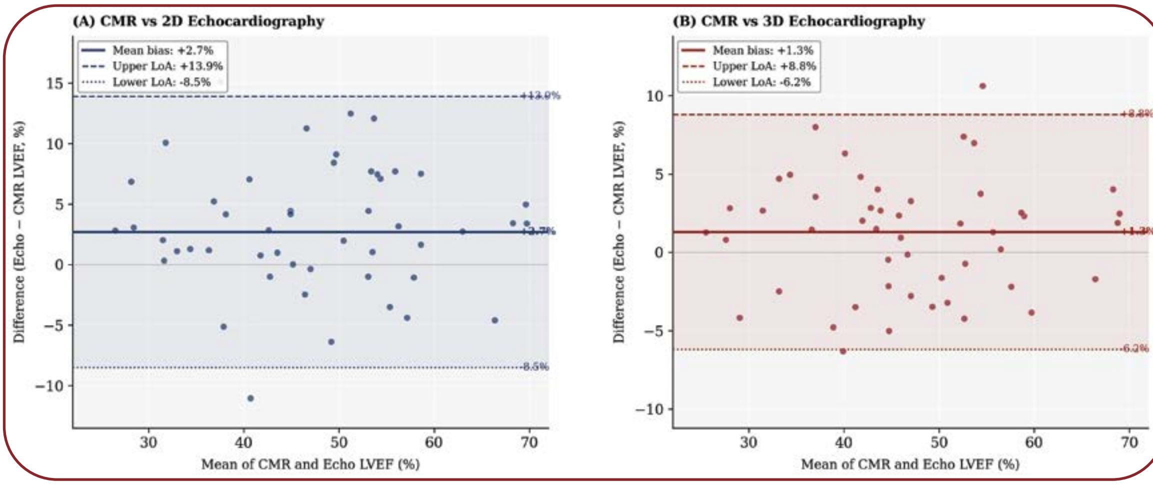

FIGURE 3. Bland-Altman agreement plots: A) CMR *versus* 2D echocardiography: mean bias +2.7%, 95% limits of agreement −8.5% to +13.9% (total range 22.4 percentage points); and B) CMR *versus* 3D echocardiography: mean bias +1.3%, 95% limits of agreement −6.2% to +8.8% (total range 15.0 percentage points). Horizontal solid line: mean bias; dashed line: upper limit of agreement; dotted line: lower limit of agreement. Proportional bias is evident in panel A, with greater overestimation at lower LVEF values.
CMR: cardiac magnetic resonance imaging; LoA: limits of agreement; LVEF: left ventricular ejection fraction.

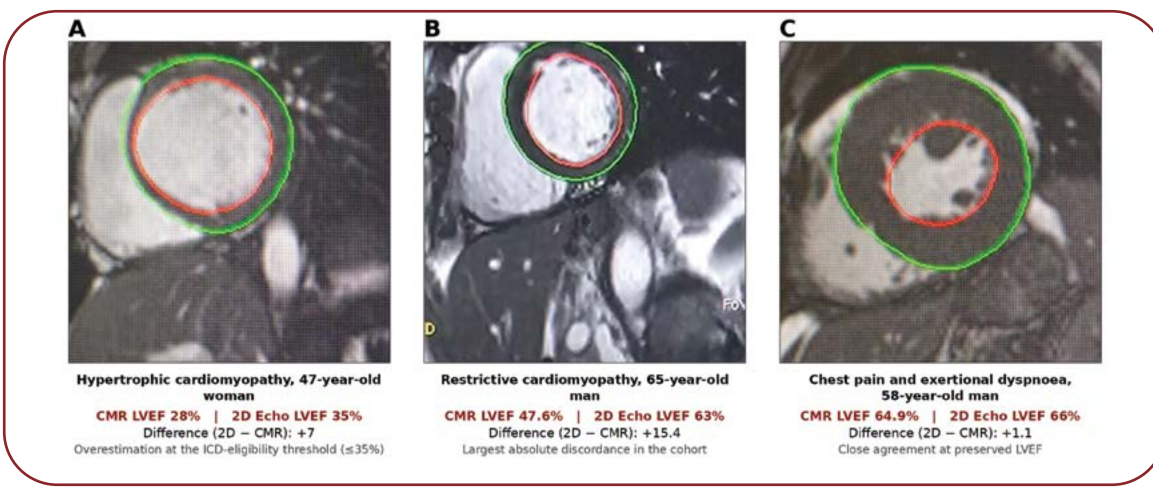

FIGURE 4. Representative cases illustrating the relationship between left ventricular ejection fraction (LVEF) discordance and the severity of left ventricular systolic dysfunction. Each panel shows a de-identified cardiac magnetic resonance (CMR) short-axis cine image with endocardial (red) and epicardial (green) contours; the CMR and two-dimensional echocardiographic (2D Echo) LVEF values are annotated beneath each panel: **A)** a 47-year-old woman with hypertrophic cardiomyopathy: 2D Echo reported an LVEF of 35% – exactly the implantable cardioverter-defibrillator (ICD)-eligibility threshold (≤35%) – whereas CMR demonstrated 28%, the most clinically consequential overestimation in the cohort; **B)** a 65-year-old man with restrictive cardiomyopathy: 2D Echo 63% *versus* CMR 47.6%, the largest absolute discordance observed (15.4 percentage points), reflecting the failure of 2D geometric assumptions in non-ellipsoidal ventricular geometry; and **C)** a 58-year-old man with chest pain and exertional dyspnoea: 2D Echo 66% *versus* CMR 64.9%, exemplifying the close agreement seen at preserved LVEF. The progressive narrowing of discordance as LVEF rises demonstrates that echocardiographic overestimation is concentrated at reduced and borderline functional states – precisely where device-therapy thresholds apply.

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LVEF reclassification

Concordance between CMR and 2D Echo was 68.0% (34/50 patients). Upward reclassification by 2D Echo occurred in 13 (26.0%) subjects, predominantly in those with true CMR-LVEF below

TABLE 6. Inter-modality agreement: Bland-Altman and ICC (n=50)

Comparison	Mean bias (%)	95% LoA (%)	ICC	95% CI	Agreement grade
CMR *vs* 2D Echo	+2.7	−8.5 to +13.9	0.89	0.81–0.94	Good
CMR *vs* 3D Echo	+1.3	−6.2 to +8.8	0.93	0.87–0.96	Excellent
CMR-LVEF *vs* GLS†	N/A	N/A	−0.87	−0.92 to −0.78	Strong (r)

†For the CMR-LVEF *versus* GLS comparison the value shown is the Pearson correlation coefficient (r), not an intraclass correlation coefficient, since GLS (strain, %) and LVEF (%) are different metrics; Bland–Altman bias and limits of agreement are therefore not applicable. CMR: cardiac magnetic resonance; ICC: intraclass correlation coefficient; CI: confidence interval; 2D Echo: two-dimensional echocardiographic; 3D Echo: three-dimensional echocardiographic; LVEF: left ventricular ejection fraction; LoA: limits of agreement; N/A: not applicable.

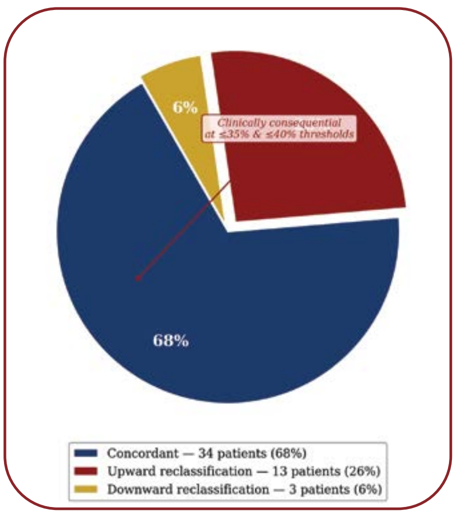

FIGURE 5. Reclassification of patients across LVEF categories: CMR *versus* 2D echocardiography (n=50). Pie chart illustrating the proportion of concordant (68%), upwardly reclassified (26%) and downwardly reclassified (6%) patients. Upward reclassification was predominantly observed in subjects with true CMR-LVEF below 40%, concentrated at the critical ≤35% ICD eligibility and ≤40% pharmacotherapy thresholds. CMR: cardiac magnetic resonance imaging; LVEF: left ventricular ejection fraction; ICD: implantable cardioverter-defibrillator.

TABLE 7. Reclassification across LVEF categories: CMR *vs* 2D Echo (n=50)

Reclassification outcome	n (N=50)	%	Clinical implication
Concordant (same LVEF category)	34	68.0	No management impact
Upward reclassification by 2D Echo	13	26.0	Potential delay in device therapy/pharmacotherapy near ≤35–40% threshold
Downward reclassification by 2D Echo	3	6.0	Potential unnecessary escalation
Total	50	100	

LVEF: left ventricular ejection fraction; CMR: cardiac magnetic resonance imaging; 2D Echo: two-dimensional echocardiographic

40%, concentrated near the critical ≤35% ICD eligibility and ≤40% pharmacotherapy thresholds. This pattern closely mirrors findings reported by Narang *et al* (11) and Krishnamurthy *et al* (12) in Indian tertiary care cohorts. Downward reclassification occurred in three patients (6.0%). Reclassification data are presented in Table 7 and Figure 5.

Global longitudinal strain

The GLS was normal (≤−18%) in 17 (34.0%) patients, mildly reduced (−15 to −17%) in 14 (28.0%), moderately reduced (−10 to −14%) in 13 (26.0%) and severely reduced (<−10%) in six (12.0%) subjects. Pearson r = −0.87 with CMR-LVEF ($p < 0.001$), confirming the strong relationship between longitudinal deformation impairment and volumetric systolic dysfunction (5, 13). Critically, seven of 20 patients (35.0%) with preserved CMR-LVEF (≥50%) demonstrated an abnormal GLS, confirming subclinical myocardial deformation impairment consistent with observations by Joseph *et al* (14) in post-infarction survivors, Holzknecht *et al* (6) in STEMI patients

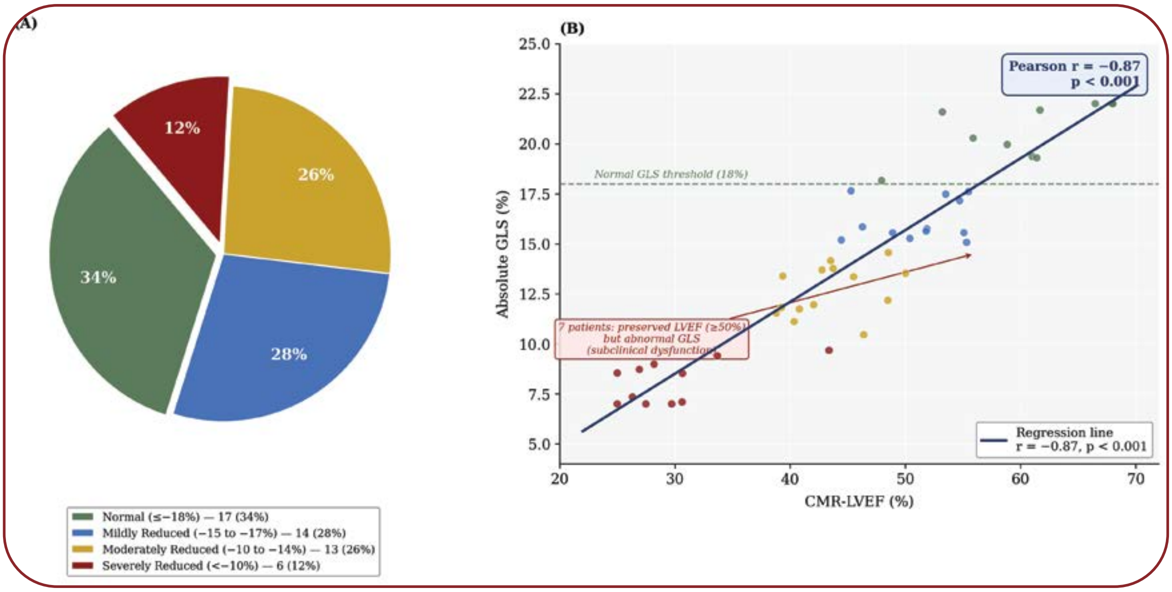

FIGURE 6. Global longitudinal strain (GLS) analysis: **A)** pie chart of GLS category distribution across the cohort: normal GLS (≤−18%) in 17 (34.0%) patients, mildly reduced (−15 to −17%) in 14 (28.0%), moderately reduced (−10 to −14%) in 13 (26.0%) and severely reduced (<−10%) in six (12.0%) subjects; **B)** scatter plot of absolute GLS *versus* CMR-LVEF with regression line (Pearson r = −0.87, p < 0.001), demonstrating a strong inverse correlation. The dashed horizontal line marks the normal GLS threshold (18%). Seven patients with preserved CMR-LVEF (≥50%) demonstrated an abnormal GLS (below threshold line), representing subclinical myocardial dysfunction. GLS: global longitudinal strain; CMR: cardiac magnetic resonance imaging; LVEF: left ventricular ejection fraction.

and – specifically in the Indian context – Nair *et al* (15), who demonstrated that speckle-tracking GLS identified occult LV dysfunction in Indian patients with preserved ejection fractions. All GLS measurements were acquired on a single platform to minimise inter-software variability (8, 9). GLS distribution and the correlation scatter plot are shown in Figure 6.

Safety profile

Four procedure-related events occurred among 50 patients (8.0%): one transient self-limiting arrhythmia during CMR, one mild gadolinium allergic reaction managed with antihistamines and two instances of mild echocardiographic probe discomfort managed with reassurance. No serious adverse events occurred. ❑

DISCUSSION

The central finding is a mean LVEF overestimation of +2.7 percentage points by 2D Echo relative to CMR, with 95% LoA spanning 22.4 percentage points. This bias is numerically identical to that reported by Solyman *et al* (7) and is mechanistically explained by the failure of the biplane ellipsoidal geometric model in remodelled ventricles, confirmed by the proportional bias pattern with greatest discordance at the lowest LVEF values, as documented by Gruszczynska *et al* (10).

3D Echo demonstrated a significantly improved agreement (ICC 0.93; LoA span 15.0 pp; p = 0.012 *vs* 2D Echo on post-hoc analysis) (1, 4), which was attributable to direct volumetric acquisition. The Bland-Altman analysis reveals that a patient with true CMR-LVEF of 28% could be measured at up to 42% by 2D Echo – crossing both the ICD eligibility and pharmacotherapy thresholds. Upward reclassification in 26% of patients mirrors findings from Narang *et al* (11) and Krishnamurthy *et al* (12) in Indian settings.

The GLS showed a strong inverse correlation with CMR-LVEF (r = −0.87). The 35% prevalence of abnormal GLS among patients with preserved CMR-LVEF identifies subclinical longitudinal subendocardial fibre dysfunction invisible to volumetric ejection fraction, which is consistent with findings from Joseph *et al* (14) and Holzknecht *et al* (6). In the Indian context, Nair *et al* (15) specifically validated this capacity of GLS for detection of occult LV impairment in patients with apparently normal ejection fractions.

These findings support a tiered multimodality imaging strategy: 2D echocardiography combined with GLS as the foundational functional screen; 3D echocardiography when precise LVEF is required; and selective CMR confirmation when echocardiographic LVEF falls near a clinical decision boundary. This framework aligns with recommendations from Sharma *et al* (16) and Patel *et al* (17) in comparable Indian tertiary care settings.

A balanced appraisal of the three modalities clarifies where each is best deployed. The principal argument in favour of 2D Echo is practical rather than metrological: it is inexpensive, portable, free of radiation and contrast and almost universally available, which sustains its role as the default first-line test. The arguments against it are the geometric assumptions of the biplane method, dependence on acoustic window and endocardial definition, foreshortening and load dependence – limitations that converge to produce the proportional overestimation observed here. 3D Echo mitigates the geometric error through direct volumetric acquisition, and a recent meta-analysis confirms its close agreement with CMR for left ventricular volumes and ejection fraction across mixed populations (18); the arguments against it are continued dependence on image quality, lower frame rates that can blur the cardiac cycle and degraded performance in atrial fibrillation or poor acoustic windows. Cardiac magnetic resonance, despite being the reference standard for the already stated reasons, is itself constrained by cost, limited availability, longer acquisition times, gadolinium considerations and incompatibility with several implanted devices – constraints that are especially salient in a resource-limited setting. The recent literature is therefore not uniformly "for" any single modality but converges on context-dependent selection, which is the rationale for the tiered strategy proposed above.

The role of GLS in the present study extends beyond that of an additional measurement. Because the longitudinal subendocardial fibres are the earliest to be affected by ischaemia, fibrosis and pressure overload, GLS becomes abnormal while the ejection fraction – a global volumetric ratio – is still preserved. In this cohort, that is not a peripheral observation but a central one: a substantial minority of patients with normal CMR-LVEF showed abnormal GLS, meaning that an approach relying on ejection fraction alone would have classified them as having normal systolic function. Integrated into the tiered pathway, GLS therefore functions as the sensitivity layer that compensates for the principal blind spot of ejection-fraction-based assessment, flagging patients who warrant closer surveillance or earlier intervention despite a reassuring LVEF. Its main interpretive caveat is that absolute strain values are not freely interchangeable between vendors and software packages, as established by the EACVI/ASE inter-vendor comparison (19); reporting GLS from a single platform, as done here, preserves internal validity, and between-study comparisons should be read with this caveat in mind.

Limitations

Several limitations qualify these findings of the present study. Firstly, the single-centre design and the modest sample of 50 patients limit statistical power, particularly within individual diagnostic subgroups, and may reduce the precision of the agreement estimates and the generalisability of the reclassification rates; the cohort nonetheless lies within the range of comparable CMR-validation studies and the direction and magnitude of the principal findings are consistent with the wider literature. Secondly, the cohort was deliberately heterogeneous, spanning ischaemic, myopathic, valvular and other pathologies; while this reflects real-world referral practice, it precludes pathology-specific agreement analysis and may obscure condition-dependent differences in echocardiographic accuracy. Thirdly, although standardised acquisition, three-cycle averaging, and blinded experienced operators were used, formal echocardiographic intra- and inter-observer variability indices were not separately computed for every measurement and are a recommended addition for future work. Fourthly, GLS was derived solely from 2D speckle-tracking on a single platform; comparison with GLS obtained by 3D Echo and CMR feature-tracking – which the present design did not permit because of vendor non-interchangeability and acquisition constraints – is a logical next step. Although CMR and echocardiography were performed within a short pre-specified interval without interval intervention, they were not invariably simultaneous, so a small physiological contribution to the observed differences cannot be excluded. A larger multicentre pathology-stratified study incorporating formal multimodality GLS comparison would address these limitations. ❑

CONCLUSIONS

In patients with cardiovascular disease, 2D Echo systematically overestimated LVEF relative to CMR, and this overestimation produced clinically meaningful reclassification near the thresholds that govern device and pharmacological therapy. Three-dimensional Echo agreed substantially more closely with CMR and is preferable whenever a precise LVEF is required from echocardiography. The GLS identified subclinical myocardial dysfunction in a meaningful proportion of patients whose LVEF appeared preserved, confirming its incremental diagnostic value. Taken together, these findings support a tiered multimodality strategy in which echocardiography combined with strain serves as the functional screen and CMR is reserved for confirmation when echocardiographic values fall near a clinical decision boundary – an approach that is both evidence-based and well suited to resource-limited tertiary-care settings. ❑

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