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Original Article

Low-tech, high-value: Electrocardiographic markers of left ventricular dysfunction in non-ischemic cardiomyopathy

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ABSTRACT

Background: Electrocardiography (ECG) is a widely accessible, cost-effective diagnostic tool, particularly valuable in resource-limited settings where echocardiography is unavailable. Identifying ECG parameters that reflect left ventricular (LV) systolic dysfunction could enable earlier detection and intervention in patients with non-ischemic cardiomyopathy (NICM).
Objective: To evaluate the correlation between ECG parameters—QTc duration, QRS duration, morphology, voltage, and axis—and left ventricular ejection fraction (LVEF) in NICM patients with reduced ejection fraction (REF), and to assess their potential as surrogate markers of LV systolic function.
Methods: A cross-sectional study was conducted on 140 NICM patients (LVEF ≤40%) confirmed by echocardiography and angiography. Clinical, biochemical, and ECG data were collected. Pearson's correlation and ANOVA were used to assess associations between ECG variables, mitral regurgitation (MR) severity, hemoglobin levels, and LVEF.
Result: QTc duration showed a significant inverse correlation with LVEF ($r = -0.428$, $p = 0.001$). Hemoglobin levels were positively correlated with LVEF ($r = 0.175$, $p = 0.039$). The presence of mitral regurgitation was associated with lower LVEF ($p = 0.029$), with a trend toward further decline as severity increased.
Conclusion: Prolonged QTc was strongly associated with reduced LVEF in patients with non-ischemic cardiomyopathy. As ECG is inexpensive and widely available, QTc may provide a simple surrogate marker to aid in identifying LV dysfunction, especially in resource-limited settings. Larger prospective studies with outcome data are needed to validate its prognostic role.

1. Introduction

Heart failure due to non-ischemic cardiomyopathy (NICM) remains a significant clinical challenge, largely because of its progressive course and the resultant deterioration of left ventricular (LV) function. As LV ejection fraction (LVEF) declines, prognosis worsens, underscoring the need for early detection and assessment.

In developing countries where echocardiography may not be consistently available, electrocardiography (ECG) provides an accessible, low-cost alternative for initial cardiac evaluation. Certain ECG parameters—such as QTc interval, QRS duration, morphology, axis, and voltage—have been associated with underlying LV dysfunction.[1] Studies have particularly emphasized the relevance of prolonged QTc and widened QRS complexes in this context. Murkofsky et al. identified QRS duration >0.10 s as a specific marker for reduced LVEF, though sensitivity was variable.[2] Similarly, Gowardhan et al. reported the effectiveness of QRS scoring systems in evaluating LV function following myocardial infarction.[3]

This study seeks to assess whether QTc duration and QRS-related parameters on ECG correlate with LVEF in patients with NICM. The goal is to explore their potential role as surrogate indicators for LV function in resource-limited settings.

Certain ECG parameters—QTc interval, QRS duration, morphology, axis, and voltage—have been investigated as potential indicators of LV dysfunction. However, prior studies largely focused on ischemic cardiomyopathy or mixed cohorts. There is limited evidence specifically addressing NICM patients in resource-constrained environments. Our study contributes by evaluating a pure NICM cohort with angiographically confirmed non-obstructive coronaries, analyzing both electrical and clinical/biochemical correlates (e.g., anemia, MR).

2. Materials and methods

This cross-sectional, observational study was conducted in the Department of Cardiology, Sir Sunderlal Hospital, Institute of Medical Sciences, Banaras Hindu University, Varanasi, between 1st July 2024 and 30th September 2024. A total of 140 patients attending the outpatient department were enrolled consecutively using a standardized and validated proforma. The primary objective was to assess the utility of electrocardiographic (ECG) parameters—including QTc duration, QRS duration, morphology, axis, and voltage—as surrogate markers of left ventricular (LV) systolic function in patients diagnosed with non-ischemic cardiomyopathy (NICM) and reduced ejection fraction (REF), defined as LVEF ≤40%.

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The study protocol received ethical clearance from the Institutional Ethics Committee of the Institute of Medical Sciences, Banaras Hindu University. Written informed consent was obtained from all participants prior to inclusion.

Sample size and power considerations

A formal a priori sample size calculation was not performed because this was a consecutive cohort study within a fixed enrollment window. To contextualize the adequacy of the sample, we conducted retrospective power analyses. Using the observed correlation between QTc and LVEF (r = −0.428) and the actual study size (n = 140), the post hoc power to detect this association at α = 0.05 (two-tailed) was >99%. With n = 140, the minimum correlation coefficient detectable with 80% power is approximately r = 0.234. By comparison, detecting a correlation of r = 0.30 would require ∼84 subjects, r = 0.25 ∼122 subjects, and r = 0.20 ∼193 subjects at the same power and significance level. For multivariable regression, the present sample provides sufficient power to detect moderate effect sizes (Cohen's $f^2 \approx 0.15$) but is underpowered for small effects ($f^2 \approx 0.02$). These analyses indicate that the sample was robustly powered to detect the main correlation of interest but may not exclude smaller associations.

Inclusion criteria comprised:

(i) Adult patients (≥18 years) diagnosed with NICM,
(ii) NICM was diagnosed per the 2022 AHA/ACC/HFSA guidelines. Mitral regurgitation severity was graded according to American Society of Echocardiography recommendations.
(iii) Written informed consent,
(iv) Baseline 2D echocardiography confirming NICM with LVEF ≤40%,
(v) Evidence of normal or non-significant coronary arteries on invasive coronary angiography or CT coronary angiography, and
(vi) Sinus rhythm on ECG.

Exclusion criteria included:

(i) History of ischemic heart disease or myocardial infarction,
(ii) Prior pacemaker implantation or conduction abnormalities affecting QRS axis/duration, and
(iii) Significant valvular heart disease.

Comprehensive clinical data were collected, including demographic details, comorbidities such as hypertension (BP ≥140/90 mmHg or on antihypertensives), diabetes mellitus (based on ADA criteria), and chronic kidney disease. NYHA functional classification and treatment history were documented. Laboratory evaluations included hemoglobin, serum creatinine, and potassium levels.

Each patient underwent a standard 12-lead ECG to evaluate QTc interval, QRS duration, axis, morphology, and voltage. QRS voltage was interpreted using Sokolow–Lyon criteria for left ventricular hypertrophy,[3] while low voltage was defined based on nadir-to-peak QRS complex measurements.[4] Echocardiographic data included LVEF, left ventricular end-diastolic diameter (LVEDD), and the presence and severity of mitral regurgitation.

Statistical analysis was performed using IBM SPSS Statistics version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Group comparisons were analyzed using independent t-tests and ANOVA. A p-value <0.05 was considered statistically significant.

3. Result

Demographic, Baseline, and Ongoing Treatment Data

The baseline characteristics of the study cohort (n=140) demonstrated a predominance of middle-aged individuals, with a mean age of 53.86 years. The largest age group included 74 patients (52.9%) between 41 and 60 years, followed by 44 patients (31.4%) aged 61 to 80 years. A smaller proportion, 22 patients (15.7%), were in the 21–40 year age group. The study population had a slight female predominance, with 78 female patients (55.7%) and 62 male patients (44.3%).

Table 1- Baseline Characteristics

Parameter	Sub-category	n (Frequency)	Percentage
Age	21-40 years	22	15.70
	41-60 years	74	52.90
	61-80 years	44	31.40
Gender	Female	78	55.70
	Male	62	44.30
Co-morbidities	CKD	14	10.00
	Diabetes mellitus	22	15.70
	Hypertension	20	14.30
	Others	4	2.90
	Hypothyroid	2	1.40
	Pulmonary TB	2	1.40
NYHA Class	I	112	80.00
	II	28	20.00
Ongoing Treatment	ARNI	84.00	60.00
	Diuretics	124.00	88.60
	MRA	102.00	72.90
	ACEi/ARBs	20.00	14.30
	SGLT2i	104.00	74.30
	Beta-blockers	128.00	91.40

CKD – Chronic Kidney Disease;NYHA – New York Heart Association (Functional Classification);ARNI – Angiotensin Receptor-Neprilysin Inhibitor;MRA – Mineralocorticoid Receptor Antagonist;ACEi/ARBs – Angiotensin-Converting Enzyme Inhibitors / Angiotensin II Receptor Blockers;SGLT2i – Sodium-Glucose Cotransporter-2 Inhibitors;TB – Tuberculosis.

Note: Percentages are calculated based on the total study cohort (n = 140).

Comorbidities and ongoing treatments are not mutually exclusive; some patients were receiving multiple drug classes concurrently or had more than one comorbidity.

Table 2- Correlation coefficient

Variables	Minimum	Maximum	Mean	Std. Deviation	Correlation coefficient	P value
LVEF	15.00	40.00	28.15	6.33		
QRS Duration	67.00	184.00	127.27	58.54	0.026	0.763
QTc Duration	340	556	449.17	41.36	-0.428	0.001*
LVEDD	45.00	86.00	60.11	7.18	-0.167	0.051
Hemoglobin	4.12	20.00	11.76	2.45	0.175	0.039*
Creatinine	0.52	11.41	1.29	1.33	0.045	0.595
Potassium	2.83	6.12	4.41	0.56	0.006	0.941

LVEF – Left Ventricular Ejection Fraction;QRS – QRS Complex Duration on ECG;QTc – Corrected QT Interval;
LVEDD – Left Ventricular End-Diastolic Dimension.
Note: Correlation coefficients were calculated using Pearson's method. $P < 0.05$ was considered statistically significant and is marked with an asterisk*.A negative correlation indicates an inverse relationship with LVEF.

Table 3- QRS Morphology, Axis, Voltage and LVEF

QRS Morphology	N	Mean	SD	Minimum	Maximum
LBBB	60	26.53	6.53	15.0	40.0
Normal	74	29.32	5.71	20.0	40.0
LAHB	2	30.00	0.00	30.0	30.0
RBBB	4	30.00	11.54	20.0	40.0
Total	140	28.15	6.33	15.0	40.0
QRS axis	**N**	**Mean**	**SD**	**Minimum**	**Maximum**
Left	58	27.00	5.94	18.0	40.0
Normal	68	28.91	6.46	15.0	40.0
North West	4	30.00	0.00	30.0	30.0
Right	10	29.00	8.43	20.0	40.0
Total	140	28.16	6.34	15.0	40.0
QRS Voltage	**N**	**Mean**	**SD**	**Minimum**	**Maximum**
Normal	56	28.12	6.30	15.0	40.0
High	60	30.20	8.24	15.0	40.0
Low	24	27.05	7.23	15.0	40.0
Total	140	28.95	6.56	15.0	40.0

LVEF – Left Ventricular Ejection Fraction; LBBB – Left Bundle Branch Block; RBBB – Right Bundle Branch Block; LAHB – Left Anterior Hemiblock.
QRS Axis Classifications: Left Axis Deviation: QRS axis between –30° and –90°;Normal Axis: QRS axis between –30° and +90°;Right Axis Deviation: QRS axis between +90° and +180°;Northwest Axis: QRS axis between –90° and ±180° (also called indeterminate axis)
QRS Voltage Criteria:High QRS Voltage: Defined using Sokolow–Lyon criteria for LVH;Low QRS Voltage: Defined as nadir-to-peak QRS amplitude below 5 mm in limb leads or 10 mm in precordial leads
Note: Mean LVEF is shown for each subgroup. No statistically significant differences were observed among groups for morphology, axis, or voltage ($P > 0.05$ for all comparisons).

Table 4 – Mitral Regurgitation-Severity and LVEF

Severity of Mitral Regurgitation	N	Mean LVEF	SD	Minimum LVEF	Maximum LVEF
Mild	30	29.67	6.85	20.0	40.0
Moderate	52	28.42	6.53	20.0	40.0
Severe	52	26.38	5.28	15.0	35.0
Total	134	27.91	6.25	15.0	40.0

LVEF – Left Ventricular Ejection Fraction; MR – Mitral Regurgitation.
Note: MR severity was assessed via transthoracic echocardiography and categorized as mild, moderate, or severe based on standard criteria (vena contracta width, regurgitant volume, and jet area). A statistically significant reduction in mean LVEF was observed in patients with MR compared to those without ($P = 0.029$). Although the mean LVEF declined progressively with increasing MR severity, this trend approached but did not reach statistical significance ($P = 0.053$). Total N = 134 reflects patients with documented MR status; 6 patients were excluded due to incomplete MR assessment.

In terms of comorbid conditions, diabetes mellitus was the most prevalent, affecting 22 patients (15.7%). Hypertension was noted in 20 patients (14.3%), while chronic kidney disease (CKD) was present in 14 patients (10.0%). Less common comorbidities included hypothyroidism and pulmonary tuberculosis, each seen in 2 patients (1.4%).

Assessment of heart failure severity using the New York Heart Association (NYHA) functional classification showed that most patients (112 patients; 80.0%) were in Class I, indicating mild symptoms. The remaining 28 patients (20.0%) were classified as NYHA Class II, suggesting slightly more advanced symptomatology.

Regarding pharmacological management, beta-blockers were the most frequently prescribed, administered to 128 patients (91.4%). Diuretics were used in 124 patients (88.6%), followed by sodium-glucose cotransporter-2 inhibitors (SGLT2i) in 104 patients (74.3%) and mineralocorticoid receptor antagonists (MRA) in 102 patients (72.9%). Angiotensin receptor–neprilysin inhibitors (ARNIs) were prescribed in 84 cases (60.0%), while angiotensin-converting enzyme inhibitors or angiotensin II receptor blockers (ACEi/ARBs) were utilized in 20 patients (14.3%).

Overall, the study cohort comprised predominantly middle-aged, female patients with relatively mild heart failure symptoms. Pharmacologic treatment was consistent with guideline-directed medical therapy, with a high prevalence of beta-blockers, diuretics, SGLT2i, and MRA use.

Association of LVEF with QTc Interval, QRS Duration, LVEDD, Hemoglobin, Creatinine, and Potassium

The mean left ventricular ejection fraction (LVEF) of the study population was 28.15% ± 6.33, with a range from 15.0% to 40.0%. A statistically significant negative correlation was observed between LVEF and QTc interval (correlation coefficient = -0.428, P = 0.001), indicating that longer QTc durations are associated with lower LVEF.

LVEF was also found to have a significant positive correlation with hemoglobin levels (correlation coefficient = 0.175, P = 0.039), suggesting that higher hemoglobin values may be linked to better systolic function.

Other variables, including QRS duration, LVEDD, creatinine, and potassium, did not demonstrate statistically significant associations with LVEF. QRS duration ranged from 67.0 to 184.0 milliseconds, showing a weak and non-significant positive correlation (correlation coefficient = 0.026, P = 0.763). LVEDD, ranging from 45.0 to 86.0 mm, showed a weak negative correlation (correlation coefficient = -0.167, P = 0.051), nearing statistical significance but not meeting the threshold. Serum creatinine (0.52 to 11.41 mg/dL) and potassium levels (2.83 to 6.12 mmol/L) also exhibited non-significant correlations (P = 0.595 and P = 0.941, respectively).

These findings highlight a strong inverse association between QTc interval and LVEF and suggest a possible link between anemia and lower systolic function in NICM.

QRS Morphology, Axis, and Voltage in Relation to LVEF

The analysis of QRS morphology revealed variations in left ventricular ejection fraction (LVEF) across different conduction patterns. Patients with left bundle branch block (LBBB), comprising 60 individuals, demonstrated a mean LVEF of 26.53% ± 6.53, with values ranging from 15.0% to 40.0%. In contrast, those with normal QRS morphology (n = 74) had a higher mean LVEF of 29.32% ± 5.71, ranging between 20.0% and 40.0%. Patients with left anterior hemiblock (LABH), although limited to two cases, each had an LVEF of 30.0%. Similarly, the right bundle branch block (RBBB) group, which included four patients, showed a mean LVEF of 30.0% ± 11.54, though with a broader distribution from 20.0% to 40.0%. The overall mean LVEF across all QRS morphology groups was 28.15% ± 6.33. Although the LBBB subgroup exhibited a trend toward lower LVEF compared to other morphologies, this difference was not statistically significant (P = 0.072).

When evaluating the QRS axis, patients with left axis deviation (n = 58) had a mean LVEF of 27.00% ± 5.94 (range: 18.0–40.0%), while those with a normal axis (n = 68) showed a slightly higher mean LVEF of 28.91% ± 6.46 (range: 15.0–40.0%). The northwest axis group (n = 4) exhibited a uniform LVEF of 30.0%, and the right axis deviation subgroup (n = 10) had a mean LVEF of 29.0% ± 8.43, ranging from 20.0% to 40.0%. The total average LVEF across all axis categories was 28.16% ± 6.34. Although patients with leftward QRS axis deviation tended to have lower LVEF, these differences did not reach statistical significance (P = 0.335).

Assessment of QRS voltage amplitude revealed a gradation in LVEF. Patients with high QRS voltage exhibited the highest mean LVEF at 30.20% ± 8.24, while those with normal voltage showed a mean LVEF of 28.12% ± 6.30. The lowest LVEF was seen in patients with low QRS voltage, averaging 27.05% ± 7.23. Despite this observed trend suggesting that higher QRS voltage may be indicative of preserved myocardial function, the association between QRS voltage amplitude and LVEF was not statistically significant.

Mitral Regurgitation (MR), Its Severity, and Association with LVEF

A statistically significant association was observed between the presence of mitral regurgitation (MR) and reduced left ventricular ejection fraction (LVEF). Patients diagnosed with MR had a mean LVEF of 27.91% ± 6.24, which was significantly lower than the mean LVEF of 33.67% ± 6.34 observed in patients without MR (P = 0.029). This finding supports the strong link between MR and impaired systolic function in patients with non-ischemic cardiomyopathy.

Further analysis of MR severity demonstrated a clear trend of progressive decline in LVEF with increasing severity of regurgitation. Patients with mild MR had a mean LVEF of 29.67% ± 6.85, those with moderate MR had an LVEF of 28.42% ± 6.53, while the severe MR subgroup exhibited the lowest mean LVEF at 26.38% ± 5.28. Although this gradient suggests a dose–response relationship between MR severity and LV systolic dysfunction, the trend narrowly missed statistical significance (P = 0.053).

4. Discussion

This study presented an analysis of electrocardiographic (ECG) parameters, including QRS duration, morphology, voltage, axis, and QTc duration, as potential surrogate markers for assessing left ventricular (LV) systolic function in patients with non-ischemic cardiomyopathy (NICM) and reduced ejection fraction (REF). This research is particularly relevant in regions where advanced imaging modalities such as echocardiography are not widely accessible. While most ECG parameters demonstrated weak and statistically non-significant correlations with LV ejection fraction (LVEF), the findings provide a valuable foundation for evaluating the role of ECG features in assessing LV function in NICM.

The observation that prolonged QRS duration was weakly associated with reduced LVEF is in agreement with prior studies that have identified such a relationship. Kashani et al. reported that prolonged QRS duration is a common finding in heart failure patients with reduced LVEF.[5] Similarly, Palmeri et al. demonstrated that QRS duration may serve as an indirect marker of myocardial injury and systolic dysfunction, particularly in the setting of ischemic cardiomyopathy.[5] These findings suggest that while QRS duration may hold value as an early marker of LV dysfunction, its predictive accuracy can vary, especially in non-ischemic etiologies. In the present study, the correlation between QRS duration and LVEF was weak and statistically insignificant (correlation coefficient = 0.026, P = 0.763), indicating that the extent of LV dysfunction in NICM may not be directly reflected by QRS duration. This interpretation aligns with findings by Engels et al., who concluded that QRS duration is not a consistently reliable marker of systolic function in such patients.[6]

In contrast, QTc duration displayed a statistically significant negative correlation with LVEF (correlation coefficient = -0.428, P = 0.001), indicating that a prolonged QTc is associated with more severe systolic dysfunction.

This finding is consistent with prior research by Davey, who reported that QTc prolongation serves as a marker of worsened LV systolic function and is also associated with an increased risk of arrhythmic events and mortality in heart failure patients.[7] QTc prolongation likely reflects myocardial electrical instability, which is exacerbated as LV dysfunction progresses, especially in the non-ischemic subset. This strengthens the case for QTc duration as a non-invasive surrogate marker in the early identification of high-risk patients with NICM.

Why QTc mattered while QRS did not: QTc reflects repolarization abnormalities and myocardial electrical instability, which may be more sensitive to diffuse myocardial disease and fibrosis than QRS parameters. Prior studies support its prognostic significance in heart failure. QRS duration, while linked to ischemic cardiomyopathy, was not independently significant here, suggesting etiology-specific differences.

Structural parameters, such as the left ventricular end-diastolic dimension (LVEDD), were also evaluated. LVEDD exhibited a weak negative correlation with LVEF (correlation coefficient = -0.167, P = 0.051), which, although not statistically significant, aligns with established understanding. An increase in LVEDD is indicative of LV dilation and adverse remodeling, hallmark features of NICM. Aleong et al. previously demonstrated a strong association between increased LVEDD and reduced systolic performance, attributing it to elevated wall stress and impaired contractility due to excessive dilation.[8]

Regarding biochemical parameters, hemoglobin levels showed a statistically significant positive correlation with LVEF (correlation coefficient = 0.175, P = 0.039). This finding underscores the importance of systemic factors in myocardial performance. Anemia is frequently observed in heart failure patients and is associated with poor outcomes. Tang et al. showed that lower hemoglobin levels are linked with worse LV function, primarily due to reduced oxygen-carrying capacity and chronic systemic inflammation.[9] The positive correlation between hemoglobin and LVEF highlights the interplay between anemia and cardiac dysfunction. Anemia reduces oxygen delivery and increases cardiac workload, contributing to worse LV performance.[9] This suggests that correcting anemia could have therapeutic implications in NICM.

Serum creatinine and potassium levels, on the other hand, showed minimal and statistically non-significant correlations with LVEF (P = 0.595 and P = 0.941, respectively). Although renal dysfunction, reflected by elevated creatinine, is known to coexist with and exacerbate heart failure through the cardiorenal syndrome, this study did not establish a direct correlation with LVEF. Bosselmann et al. had previously shown that worsening renal function independently predicts reduced LVEF and adverse outcomes in heart failure.[10] Similarly, potassium levels, though often abnormal in patients with heart failure or those on renin-angiotensin-aldosterone system inhibitors, did not demonstrate a significant correlation with systolic function in our cohort. However, prior work by Hoppe et al. highlighted the impact of potassium imbalances—especially hyperkalemia—on cardiac electrophysiology and function.[11]

The analysis of QRS morphology and axis yielded insights into their relationship with LVEF. Patients with left bundle branch block (LBBB) exhibited a lower mean LVEF (26.53%) compared to those with normal QRS morphology (29.32%) or other conduction patterns. However, this difference did not reach statistical significance (P = 0.072). Although LBBB has been associated with poorer prognosis and more advanced heart failure in several prior studies, its direct impact on LVEF, especially in NICM, remains less clearly defined. The absence of statistical significance in our findings may suggest that in NICM, factors such as myocardial fibrosis and ventricular remodeling may exert a stronger influence on systolic function than conduction delays alone.

Similarly, while patients with left axis deviation had marginally lower LVEF than those with normal or rightward axes, no significant differences were observed across QRS axis categories (P = 0.335). This suggests that axis deviation may not be a robust independent predictor of systolic function in NICM, although it may still reflect underlying structural or conduction system abnormalities.

With regard to QRS voltage amplitude, individuals with high QRS voltage had the highest mean LVEF (30.20% ± 8.24), followed by those with normal voltage (28.12% ± 6.30), and then low QRS voltage (27.05% ± 7.23). Although the observed trend suggests a potential association between higher voltage and preserved systolic function, this relationship was not statistically significant. Previous studies have reported mixed results in this regard. For instance, García-Escobar et al. found a significant positive correlation between QRS voltage and LVEF, attributing high voltage to better myocardial mass and contractility.[12] Our findings, although directionally consistent, suggest that QRS voltage alone may not serve as a reliable predictor of systolic function, possibly due to confounding factors such as myocardial scarring, lead positioning, or body habitus.

One of the more significant findings of this study was the relationship between mitral regurgitation (MR) and LVEF. Patients with MR had a significantly lower mean LVEF compared to those without MR (P = 0.029), underscoring the strong association between valvular insufficiency and impaired systolic function. Furthermore, although increasing severity of MR corresponded with progressively lower LVEF—mild MR (29.67%), moderate MR (28.42%), and severe MR (26.38%)—this trend narrowly missed statistical significance (P = 0.053). These observations are consistent with prior research by Pagnesi et al., who emphasized that MR, especially in the context of heart failure, significantly worsens prognosis and contributes to LV dilation and systolic dysfunction.[13]

Potential confounding factors may have influenced the observed association between QTc and LVEF. First, pharmacological therapy is a key confounder: beta-blockers, ACE inhibitors/ARBs, mineralocorticoid receptor antagonists, and antiarrhythmic agents are known to affect both ventricular remodeling and repolarization indices. Although most patients in our cohort were on guideline-directed medical therapy, heterogeneity in drug type, dosing, and adherence may have introduced variability. Second, comorbidities such as diabetes, hypertension, and chronic kidney disease can independently prolong QTc and impair left ventricular function through structural, metabolic, or autonomic pathways. While we adjusted for major comorbid conditions, residual confounding cannot be excluded. Third, gender differences merit attention: women typically have longer baseline QTc intervals, while men more frequently exhibit reduced LVEF in cardiomyopathy cohorts. This sex-specific divergence could partly explain variability in the QTc–LVEF relationship, particularly in a relatively modest sample size. Future studies with larger, more balanced cohorts and stratified analyses are required to clarify the extent to which these confounders influence the observed associations.

This study has several limitations. First, it was conducted at a single tertiary-care center, which may limit the generalizability of the findings to broader or more diverse populations. Second, the study duration was relatively short and follow-up data on long-term clinical outcomes such as hospitalization, arrhythmic events, or mortality were not available. Consequently, while the cross-sectional associations between QTc and LVEF are robust, their prognostic implications remain uncertain. Third, the modest sample size, although adequately powered to detect the primary correlation of interest, was underpowered to exclude smaller associations or to perform detailed subgroup analyses. Fourth, potential confounding factors—including variation in medical therapy, presence of comorbidities such as diabetes or chronic kidney disease, and gender-related differences in repolarization—may have influenced the observed results despite adjustment for major covariates. Finally, the absence of serial ECG and echocardiographic assessments precludes evaluation of temporal changes in QTc or LVEF with disease progression or therapy. These limitations highlight the need for larger, multicenter studies with longitudinal follow-up to confirm and extend the present findings.

5. Conclusion

QTc prolongation is strongly associated with reduced left ventricular systolic function in patients with non-ischemic cardiomyopathy. Given the wide availability and low cost of ECG, QTc may serve as a pragmatic surrogate marker to screen for LV dysfunction, particularly in resource-limited settings where echocardiography is less accessible. However, its utility should be validated in larger, multicenter cohorts with longitudinal follow-up to clarify prognostic value and refine risk stratification.

6. Declaration

6.1 Ethics Approval and Consent to participate

Ethical committee approval of the Institutional Ethical committee was obtained. All participants provided informed written consent prior to inclusion in the study.

6.2. Consent for publication
Not applicable.

6.3 Availibility of data and materials
Data used in our study were presented in the main text.

6.4 Competing interests
Not applicable.

6.5 Funding Source
Not applicable.

6.6 Authors contributions
Idea/concept: SG,AT. Design: SG,AT. Control/supervision: VA,SG. Data collection/processing: AT,KA,SK,LK. Analysis/interpretation: AT,KA,SK,LK. Literature review: AT,SG,SK,LK,KA. Writing the article: AT,SG,SK,LK,KA,VA. Critical review: SG,VA. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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