

QT Prolongation Following Premature Ventricular Contractions: A Potential Marker of Concealed Long QT Syndrome

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Abstract

Background: Long QT syndrome (LQTS) predisposes individuals to malignant ventricular arrhythmias and sudden cardiac death; however, diagnosis remains challenging in patients with borderline corrected QT (QTc) values. Premature Ventricular Contractions (PVCs) may unmask concealed abnormalities of ventricular repolarization.

Aim: To determine whether post-PVC QTc prolongation can differentiate patients with confirmed LQTS, healthy controls, and borderline index cases.

Methods: In this retrospective study, 24-hour electrocardiography (ECG) recordings from 84 subjects were analyzed, including 10 patients with confirmed LQTS, 72 healthy controls, and 2 index patients with borderline baseline QTc values. QTc intervals before and after PVCs were measured manually and corrected using Bazett's formula. Between-group differences were evaluated using analysis of covariance (ANCOVA) adjusted for baseline QTc, whereas within-group changes were assessed with paired t-tests. A two-tailed $p < 0.05$ was considered statistically significant.

Results: Post-PVC QTc intervals were longer in patients with LQTS than in healthy controls (488 ± 23 ms vs 391 ± 37 ms; adjusted $p = 0.066$). Overall, PVCs were associated with a mean QTc increase of $+15.7$ ms (95% CI 7.1–24.3; $p = 0.0005$), with larger increases observed in LQTS patients ($+22.3$ ms; $p = 0.0019$) compared with healthy controls ($+10.0$ ms; $p = 0.0098$). The two index patients exhibited marked QTc prolongation, rising from borderline baseline values (360–460 ms) to 540–600 ms ($\Delta \approx 165$ ms).

Conclusion: PVC-induced QTc prolongation may help distinguish healthy individuals from patients with overt or borderline LQTS. Whereas healthy controls demonstrated mild physiologic adaptation, patients with confirmed LQTS showed consistent QTc prolongation, and index patients exhibited marked post-PVC increases suggestive of concealed repolarization abnormalities. Assessment of QTc following PVCs may represent a simple bedside approach to improve diagnostic accuracy and risk stratification in LQTS; prospective studies in larger cohorts are warranted to confirm these findings.

Keywords: Long QT Syndrome; Ventricular Premature Complexes; Cardiac Arrhythmias.

Introduction

Long QT syndrome (LQTS) is a disorder of myocardial repolarization associated with an increased risk of malignant ventricular arrhythmias and sudden cardiac death.^{1–3} It may be congenital or acquired and often remains underdiagnosed, particularly in patients with borderline or concealed QT interval prolongation. Despite established diagnostic criteria,

identifying these patients remains clinically challenging and may delay appropriate risk stratification and management.

Premature Ventricular Contractions (PVCs) are common ventricular arrhythmias that may influence ventricular repolarization. Previous studies suggest that PVCs can modulate QT interval dynamics and other repolarization markers; however, their effects in patients with LQTS have not been systematically evaluated.^{4,5}

While PVCs have been studied in patients with uremia, frequent ectopy, and PVC-induced cardiomyopathy, little is known about their impact on QT interval behavior in patients with LQTS. Specifically, post-PVC QT prolongation has not been systematically evaluated as a potential diagnostic marker in cases of concealed or borderline LQTS. Such patients often fall below conventional QTc diagnostic thresholds yet remain at risk for malignant arrhythmias. Identifying a reliable marker

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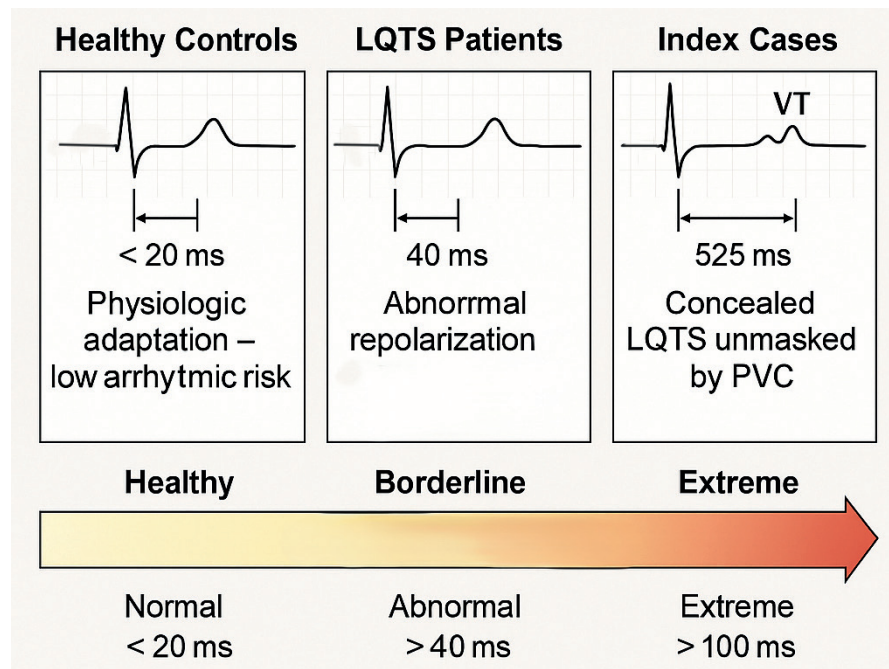
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Central Illustration: QT Prolongation Following Premature Ventricular Contractions: A Potential Marker of Concealed Long QT Syndrome

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in this subgroup could significantly enhance clinical diagnosis and risk assessment.

This study aimed to investigate whether post-PVC QT prolongation can unmask concealed LQTS by comparing patients with confirmed LQTS, healthy controls, and borderline index patients.

Methods

This study was conducted at Geo-Hospitals, Tbilisi, Georgia, from May 2025 to September 2025. A total of 84 patients with PVCs were enrolled.

Due to the condition under investigation being relatively uncommon, an a priori sample size calculation was not feasible. Therefore, all consecutive eligible patients identified during the study period were included in the analysis. Given the sample size and study design, the findings should be considered exploratory.

The study protocol was approved by the institutional ethics committee of Geo-Hospitals, and written informed consent was obtained from all participants.

Inclusion and Exclusion Criteria

Patients aged 18–67 years with PVCs confirmed by clinical evaluation and electrocardiography (ECG) findings were eligible for inclusion (Table 1).

Exclusion criteria included:

- Known congenital arrhythmias or structural heart disease;
- Severe ventricular arrhythmias;
- Active infection or significant electrolyte imbalance;
- Atrial fibrillation, ventricular bigeminy, or poor-quality ECG recordings;
- Pregnancy or lactation;
- Use of medications known to significantly affect the QT interval or arrhythmic risk (including selected antiarrhythmic agents, chemotherapeutic agents, and immunosuppressants).

Data Collection

Demographic and clinical data were obtained through structured patient interviews and review of medical records. Collected variables included age, sex, comorbidities (e.g., hypertension, diabetes mellitus), and medication history. Genetic testing was not routinely performed in this cohort. Therefore, the diagnosis of LQTS was established based on clinical criteria, including the Schwartz score and electrocardiographic findings.

Venous blood samples were collected to assess serum electrolyte levels, including potassium, magnesium, and calcium.

Table 1 – Demographic and Electrophysiological Characteristics of Study Participants

Characteristic	Value
Study population, n	84
Study groups, n (%)	
Control group	72 (85.7%)
Confirmed LQTS group: n (%)	10 (11.9%)
Index group	2 (2.4%)
Age (years), mean $\pm$ SD	55.2 $\pm$ 14.0
Gender, n (%)	
Female	49 (59.8%)
Male	33 (40.2%)
QTc before PVC (ms), mean $\pm$ SD	390.6 $\pm$ 39.3
Post-PVC QTc (ms), mean $\pm$ SD	411.2 $\pm$ 50.2
ΔQTc (QTc after – QTc before, ms), mean $\pm$ SD	9.9 $\pm$ 22.3

Electrocardiographic Assessment

All participants underwent standard 12-lead ECG. QT intervals were measured manually, and the lead demonstrating the longest QT interval, most commonly lead II, was used for analysis. The corrected QT interval (QTc) was calculated using Bazett's formula ($QTc = QT / \sqrt{RR}$). QTc was calculated using the RR interval preceding the measured beat within the same cardiac cycle. No additional RR averaging was performed. QTc prolongation was defined according to established guideline thresholds as a QTc interval > 450 ms in men and > 470 ms in women. Values between 440–470 ms in men and 450–480 ms in women were considered borderline.

Patients with prolonged QTc intervals were further evaluated for the presence of arrhythmias. ECG morphology was assessed to identify clinically significant rhythm disturbances, including atrial arrhythmias (atrial fibrillation and atrial flutter) and ventricular arrhythmias (ventricular tachycardia and torsades de pointes). Sinus arrhythmia, bradycardia, and other relevant rhythm abnormalities were also documented.

Laboratory analyses were performed on the same blood samples and included renal function tests (serum creatinine and blood urea nitrogen) and electrolyte measurements.

Statistical Analysis

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean $\pm$ standard deviation (SD) and presented with corresponding 95% confidence intervals (CIs) where appropriate.

The normality of continuous variables was assessed using the Shapiro–Wilk test. Homogeneity of variance was evaluated prior to group comparisons.

Between-group differences in post-PVC QTc duration were evaluated using Analysis of Covariance (ANCOVA), adjusted for baseline QTc values. When the assumption of homogeneity of variance was violated, Welch's correction was applied for group comparisons.

Within-group comparisons of QTc values before and after PVCs were performed using paired Student's t-tests.

Because of the very small number of index cases, these patients were analyzed descriptively and excluded from formal inferential statistical testing.

All statistical tests were two-tailed, and a p-value < 0.05 ($\alpha = 0.05$) was considered statistically significant.

Results

A total of 84 participants were included: 10 patients with confirmed LQTS, 72 healthy controls, and two index patients with borderline baseline QTc values. Patients with LQTS demonstrated longer post-PVC QTc intervals compared with healthy controls. After adjustment for baseline QTc values, this difference approached statistical significance. Within-group analysis showed that PVCs were associated with QTc prolongation across the cohort. The magnitude of this increase was greater in patients with LQTS, whereas healthy controls demonstrated only mild QTc adaptation. The two index patients appeared as clear outliers with marked post-PVC QTc prolongation. Although formal statistical testing was not feasible due to the very small sample size, these cases illustrate how PVC-induced QTc changes may unmask concealed repolarization abnormalities. A scatter plot comparing baseline QTc before PVC with QTc after PVC is shown in Figure 3. Healthy controls clustered close to the line of identity, reflecting minimal QT interval adaptation. In contrast, LQTS patients were consistently shifted upward, indicating systematic post-PVC QTc prolongation. The two index patients appeared as striking outliers, highlighting marked repolarization delay after PVCs.

Figure 3 shows scatter plot illustrating the relationship between QT interval behavior before and after a PVC. Baseline QTc before PVC is plotted on the x-axis and Post-PVC QTc on the y-axis. The dashed diagonal line represents the line of identity ($y = x$). Healthy controls cluster close to the identity line, indicating minimal QT interval adaptation after PVCs. In contrast, patients with LQTS demonstrate an upward shift consistent with post-PVC QTc prolongation. The two index patients appear as clear outliers with marked QTc prolongation following PVCs.

Figure 4 shows the group mean QTc values before and after PVCs. Patients with LQTS demonstrated higher baseline and post-PVC QTc values compared with healthy controls. The index patients showed marked QTc prolongation following PVCs with greater variability, whereas healthy controls exhibited only modest changes.

Table 2 summarizes QTc behavior before and after PVCs across the study groups. Confirmed LQTS patients exhibited consistently prolonged QTc intervals with further prolongation after PVCs, while healthy controls showed only mild changes consistent with physiologic adaptation. The index patients

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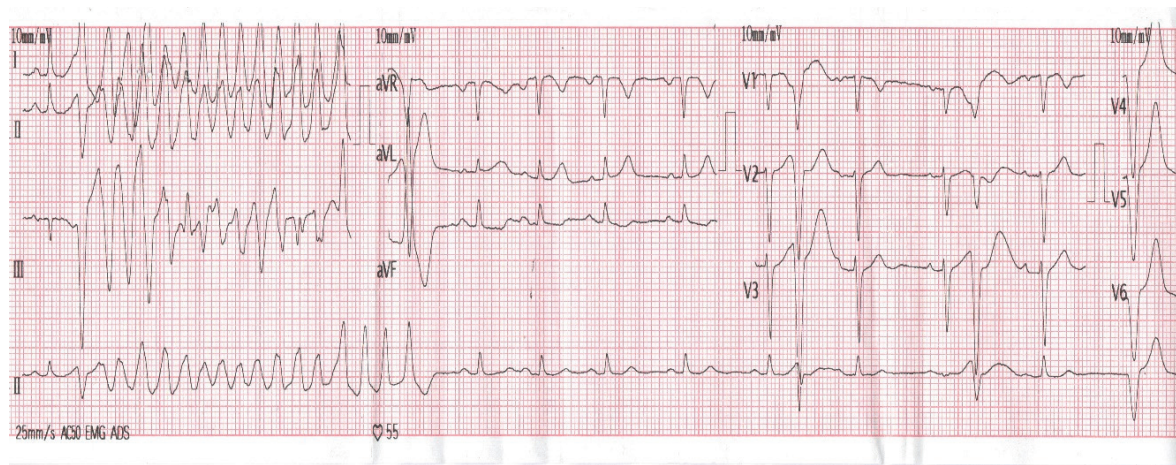
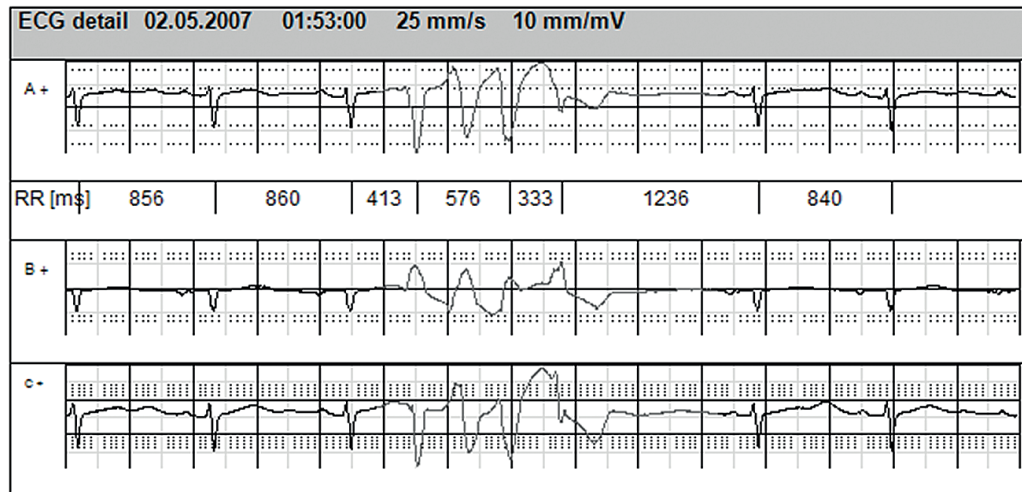


Figure 1 - Index Patient 1.

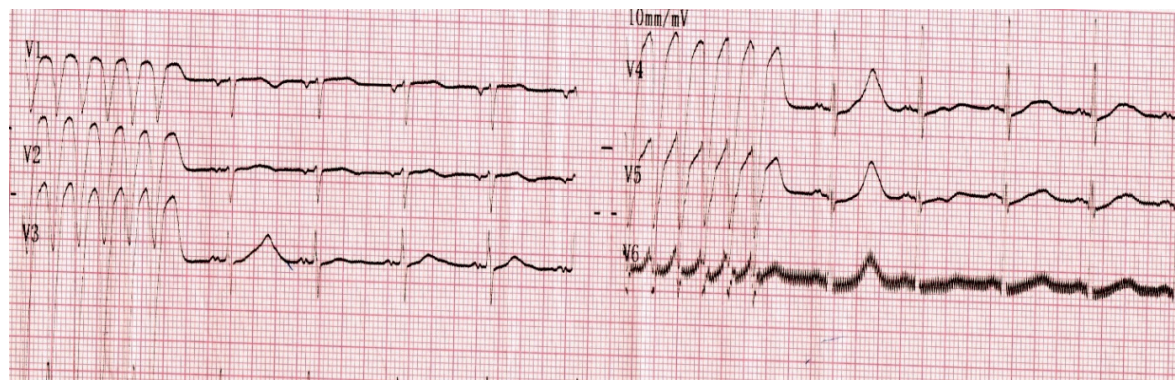


Figure 2 - Index Patient 2.

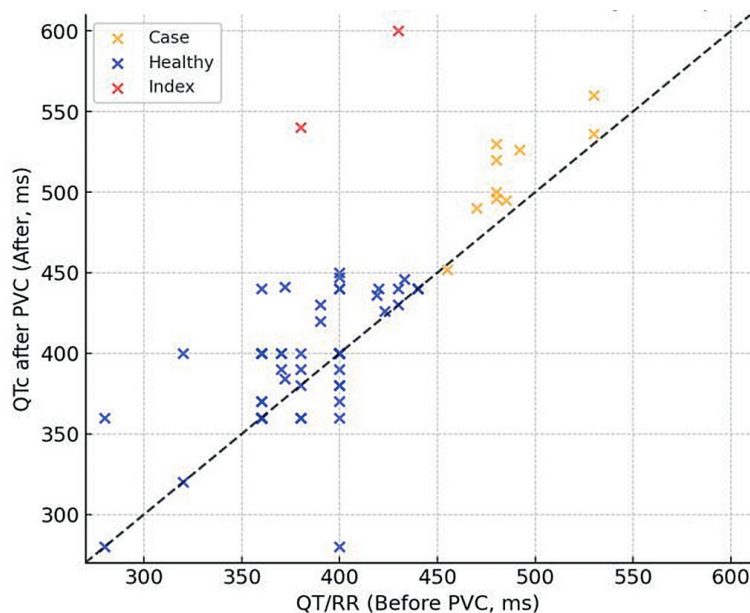


Figure 3 – Post -PVC QTc Prolongation Across Study Groups. QTc: corrected QT; PVC: Premature Ventricular Contractions.

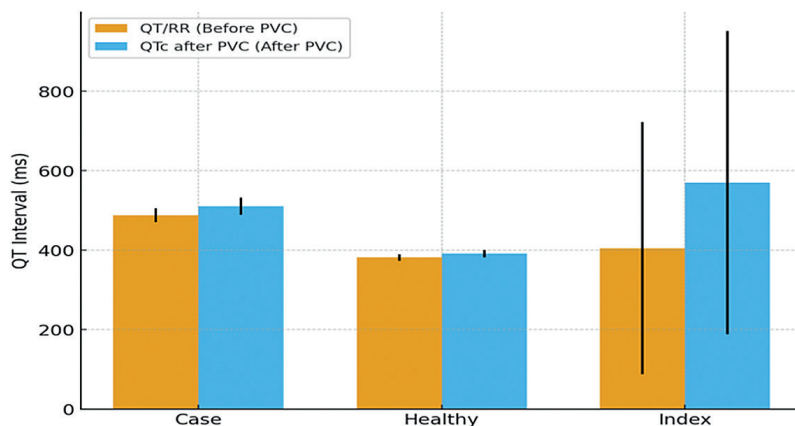


Figure 4 – Post -PVC QTc Prolongation Across Study Groups. QTc: corrected QT; PVC: Premature Ventricular Contractions.

demonstrated marked QTc prolongation after PVCs, suggesting concealed repolarization abnormalities.

Discussion

This study demonstrates that PVCs reveal important differences in repolarization response across groups. As shown in the Central Illustration, healthy controls showed only mild Post-PVC QTc prolongation (< 20 ms), consistent with normal physiologic adaptation and low arrhythmic risk. In contrast, patients with confirmed LQTS exhibited larger increases (> 40 ms) and markedly prolonged post-PVC QTc

(> 520 ms), supporting abnormal repolarization and increased susceptibility to arrhythmia (Figures 1 and 2).

The two index patients provided the most striking illustration. Despite borderline baseline QTc values, both showed marked post-PVC prolongation (> 540 ms, $\Delta \approx 165$ ms) and sustained ventricular tachycardia. Their outlier position in the scatter plot and dramatic change in the summary table underscore how PVC-induced QTc measurement can unmask concealed LQTS that might remain undiagnosed on resting ECG. Although statistical inference was not possible, these cases highlight the method's potential diagnostic and clinical value.

Table 2 – Summary of QTc behavior before and after PVCs across study groups.

Group	Baseline QTc (ms)	Post-PVC QTc (ms)	Δ QTc (ms)	Clinical Implication
Confirmed LQTS (n = 10)	Prolonged (> 480 ms)	Markedly prolonged (> 520 ms)	Large (> 40 ms)	Consistent with abnormal repolarization and higher arrhythmic risk
Index patients (borderline QTc, n = 2)	Borderline (360–460 ms)	Markedly prolonged (540–600 ms)	Very large (~165 ms)	Suggests concealed LQTS; diagnostic clue
Healthy Controls (n = 72)	Normal (< 440 ms)	Mild prolongation (< 460 ms)	Small (< 20 ms)	Physiologic adaptation; low risk

QTc: corrected QT; LQTS: Long QT syndrome.

The combination of statistical results, figures, and clinical summary emphasizes a progressive spectrum of post-PVC QTc response: small and physiologic in healthy individuals, consistent and abnormal in LQTS, and marked in borderline/index patients. These findings support the concept of PVCs as a simple bedside stress test to reveal latent repolarization abnormalities.

The results of this study are consistent with previous reports that dynamic repolarization markers may improve diagnostic accuracy in LQTS. The ability of PVCs to provoke measurable QTc changes could provide an additional tool in cases where baseline QTc is borderline or inconclusive. From a clinical perspective, systematic evaluation of post-PVC QTc may assist in risk stratification and guide closer monitoring or genetic testing.

Limitations

This study has several limitations. First, the retrospective design may introduce selection bias. Second, the sample size was modest, particularly in the index group, which limits statistical inference. Third, QT measurements were obtained from Holter recordings rather than standardized 12-lead ECGs, which may affect measurement precision. Finally, the absence of systematic genetic testing represents a limitation, as genotype–phenotype correlations could not be assessed.

Conclusion

PVC-induced QTc prolongation may aid in differentiating healthy individuals, patients with overt LQTS, and those with borderline presentations. While healthy controls showed only mild physiologic adaptation, patients with confirmed LQTS demonstrated consistent abnormal prolongation, and index patients exhibited marked post-PVC QTc increases that unmasked concealed disease. These findings support the potential clinical utility of post-PVC QTc assessment as a simple bedside tool to enhance diagnostic accuracy and refine risk stratification in LQTS. Future prospective studies in larger, well-characterized cohorts are warranted to validate these observations and further define their clinical applicability.

Author Contributions

Conception and design of the research: Jalabadze K, Machavariani P, Avaliani; acquisition of data: Jalabadze K, Tsiklauri B; analysis and interpretation of the data: Jalabadze K, Tsiklauri B, Garuchava N; statistical analysis: Garuchava N; writing of the manuscript: Jalabadze K, Machavariani P, Tsiklauri B, Garuchava N; critical revision of the manuscript for intellectual content: Machavariani P, Tsiklauri B, Avaliani I, Chigogidze M.

Potential Conflict of Interest

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

Sources of Funding

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Study Association

This article is part of the Doctoral thesis submitted by Khatuna Jalabadze, from Tbilisi State University.

Ethics Approval and Consent to Participate

This study was approved by the GeoHospitals Ethics Committee under the protocol number 25-05/404/2. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

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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