ORIGINAL ARTICLE

Comparison of Corrected QT Interval Prolongation in Young and Middle-aged Adults after First-time ST-Elevation Myocardial Infarction at Cardiac Care Facility: A Cross-Sectional Study

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ABSTRACT

Objective: To compare corrected QT interval prolongation in young and middle-aged adults after first-time ST-elevation myocardial infarction and to determine its association with selected clinical variables.

Study Design: Analytical cross-sectional study.

Place and Duration of Study: This study was conducted at Department of Adult Cardiology, Armed Forces Institute of Cardiology/National Institute of Heart Diseases (AFIC/NIHD), Rawalpindi, Pakistan, from 16th October 2025 to 15th March 2026.

Methods: A total of 296 patients with first-time ST-elevation myocardial infarction were enrolled by non-probability consecutive sampling. Patients were classified as young adults (18-45 years) and middle-aged adults (46-65 years). Patients with previous myocardial infarction, congenital long QT syndrome, bundle branch block, paced rhythm, use of QT-prolonging drugs, severe electrolyte abnormalities other than the studied potassium variation, or incomplete clinical, electrocardiographic, laboratory, or echocardiographic data were excluded. Corrected QT interval prolongation was defined as >450 ms in males and >460 ms in females.

Results: Overall, corrected QT interval prolongation was present in 75 (25.3%) patients. Mean corrected QT interval was significantly higher in middle-aged adults than young adults (448.17±14.59 ms versus 436.84±13.91 ms; *P*<0.001), and corrected QT interval prolongation was more frequent in middle-aged adults (33.1% versus 17.6%; *P*=0.002). Prolongation was significantly associated with diabetes mellitus (*P*=0.049) and site of infarction (*P*=0.014). Patients with a prolonged corrected QT interval were older, had higher heart rates, lower serum potassium levels, and lower left ventricular ejection fractions.

Conclusion: Corrected QT interval prolongation was common after first-time ST-elevation myocardial infarction and was significantly more frequent in middle-aged adults. It may serve as a simple marker of higher clinical and electrophysiological risk, especially in patients with adverse metabolic, infarct-related, and hemodynamic factors.

Keywords: *Electrocardiography, Left Ventricular Dysfunction, Middle Aged, Myocardial Infarction, Young Adult.*

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Introduction

ST-elevation myocardial infarction remains a time-critical presentation of acute coronary syndrome and requires rapid diagnosis, early risk stratification, and prompt reperfusion to reduce myocardial injury and death.[1] Although outcomes have improved with primary percutaneous coronary intervention and modern antithrombotic therapy, ventricular arrhythmias remain an important cause of early morbidity and mortality after ST-elevation

myocardial infarction.[2,3] In a recent cohort of 174,126 patients treated with primary percutaneous coronary intervention, 8.9% developed ventricular tachycardia or ventricular fibrillation after the procedure, and 2.4% developed late ventricular arrhythmias, both of which were associated with higher in-hospital mortality.[3] These observations highlight the need for simple electrocardiographic markers that can identify higher-risk patients early in the course of infarction.

The corrected QT interval is an easily obtainable electrocardiographic parameter that reflects the total duration of ventricular depolarization and repolarization after adjustment for heart rate.[4] During acute myocardial infarction, ischemia-related ionic imbalance, autonomic activation, and heterogeneity of repolarization may prolong the corrected QT interval and increase electrical instability.[5] Recent studies support its prognostic value in acute coronary syndromes and acute myocardial infarction. El Amrawy AM et al. showed that prolonged corrected QT interval predicted in-hospital mortality in acute coronary syndrome, while Wei X et al. reported that corrected QT interval values derived from different correction formulas independently predicted in-hospital major adverse cardiovascular and cerebrovascular events.[4,5] Naveen et al also found that the corrected QT interval was significantly longer in acute myocardial infarction patients who developed arrhythmias and correlated positively with the Global Registry of Acute Coronary Events score.[6]

Myocardial infarction in younger adults is increasingly recognized as a distinct clinical entity with both traditional and emerging risk factors.[7,8] Recent studies have shown that younger patients more commonly smoke, whereas older adults more frequently have hypertension, diabetes mellitus, and a broader burden of conventional cardiovascular disease.[9,10] Age-stratified outcome data in coronary artery disease have also used the categories younger than 45 years and 46 to 65 years, supporting the clinical relevance of the age groups used in the present study.[11] Despite growing evidence that corrected QT interval prolongation is associated with adverse outcomes in myocardial infarction, direct comparison between young and middle-aged adults with first-time ST-elevation myocardial infarction remains limited. This gap is important because age-related differences in repolarization abnormality may improve early risk stratification and help clinicians recognize patients who need closer monitoring and timely correction of modifiable factors during acute management.

The objective of this study was to compare corrected QT interval prolongation in young and middle-aged adults after first-time ST-elevation myocardial infarction and to determine its association with selected clinical variables.

Methods

This analytical cross-sectional study was conducted at Department of Adult Cardiology, Armed Forces Institute of Cardiology/National Institute of Heart Diseases (AFIC/NIHD), Rawalpindi, Pakistan, from 16th October 2025 to 15th March 2026. Ethical approval was obtained from the Institutional Ethical Review Board, Armed Forces Institute of Cardiology/National Institute of Heart Diseases, Rawalpindi, vide approval letter no: 9/2/R&D/2025/386, dated: 16th October 2025.

The sample size was calculated using the single-population proportion formula with a 95% confidence level, a 5% margin of error, and an expected frequency of corrected QT interval prolongation of 26%, as reported in a recent ST-elevation myocardial infarction study.[11] The final sample size was 296 patients. Patients aged 18 to 65 years of either sex presenting with first-time ST-elevation myocardial infarction were enrolled by consecutive non-probability sampling. For comparison, patients were classified as young adults (18-45 years) and middle-aged adults (46-65 years). Patients with previous myocardial infarction, congenital long QT syndrome, bundle branch block, paced rhythm, use of QT-prolonging drugs, severe electrolyte abnormalities other than the studied potassium variation, or incomplete clinical, electrocardiographic, laboratory, or echocardiographic data were excluded. Corrected QT interval prolongation was defined as >450 ms in males and >460 ms in females.

Data were prospectively collected at the bedside using a standardized questionnaire that recorded demographics, clinical details, timing variables, and ECG-based QT/QTc measures. Laboratory values and echocardiographic findings (LVEF) were extracted

within the same time window, while clinical care proceeded without interference. Key quantitative (e.g., QTc, vital signs, laboratory parameters) and qualitative variables (e.g., age group, comorbidities, outcomes) were documented. Potential confounders, including heart rate, electrolytes, medications, renal function, and infarct characteristics, were recorded to minimize bias. A standard 12-lead electrocardiogram (ECG) was obtained at the time of presentation to the emergency department before reperfusion therapy, including primary percutaneous coronary intervention or thrombolysis. ECG acquisition was performed within the first hour of hospital admission under standardized conditions with a paper speed of 25 mm/s and calibration of 10 mm/mV. QT interval measurements were performed manually by two independent cardiology-trained physicians using lead II or V5, selecting the lead with the clearest T-wave termination. In cases of discrepancy, a consensus reading was obtained. The QT interval was measured from the beginning of the QRS complex to the end of the T wave, excluding U waves when present. Corrected QT interval (QTc) was calculated using Bazett's formula ($QTc = QT/\sqrt{RR}$).

Data was analyzed using SPSS version 23. Continuous variables (e.g., heart rate, QT, QTc, QRS duration) were summarized as mean ± standard deviation for normally distributed data or median (interquartile range) for non-normally distributed data (age), while categorical variables (including sex, age group, comorbidities) were expressed as frequencies and percentages. Normality was assessed using the Shapiro–Wilk test. Between-group comparisons of QTc on index ECG among young (18–45 years) and middle-aged adults (46–65 years) was performed using the independent samples t-test or Mann–Whitney U test as appropriate. The frequency of QTc prolongation between groups was compared using the Chi-Square test. To adjust for potential confounders, linear regression was applied with QTc as the dependent variable and age group as the primary predictor. A *P*-value <0.05 was considered statistically significant.

Results

A total of 296 patients with first-time ST-elevation myocardial infarction were included, with 148 (50.0%) young adults and 148 (50.0%) middle-aged adults. The mean age of the study population was 45.5(38.0-58.0) years. Most patients were male (81.8%). Hypertension was present in 40.2%, diabetes mellitus in 23.6%, and smoking in 43.6% of the study population (Table 1).

When the primary outcome was compared between the two age groups, middle-aged adults had a significantly higher mean corrected QT interval than young adults (448.17±14.59 ms versus 436.84±13.91 ms; *P*<0.001). Corrected QT interval prolongation was also significantly more frequent in middle-aged adults than in young adults, being present in 49 (33.1%) versus 26 (17.6%) patients, respectively (Table 2).

With regard to demographic and cardiovascular risk factors, corrected QT interval prolongation was observed in 88% of males and 12% of females, but this difference was not statistically significant (*P*=0.105). Similarly, no significant association was found between corrected QT interval prolongation and hypertension (*P*=0.967) or smoking (*P*=0.089).

Corrected QT interval prolongation also varied significantly according to the site of infarction (*P*=0.014). It was most frequent in anterior infarction, where 50 patients (32.9%) had prolonged corrected QT interval, followed by other/extensive infarction in 3 patients (21.4%), inferior infarction in 19 patients (19.0%), and lateral infarction in 3 patients (10.0%)

When quantitative variables were compared according to corrected QT interval status, patients with corrected QT interval prolongation were significantly older than those without prolongation (52.15±10.63 versus 46.90±10.53 years; *P*<0.001). They also had significantly higher heart rate (90.59±8.42 versus 81.95±10.38 beats/min; *P*<0.001), lower serum potassium (3.94±0.23 versus 4.08±0.23 mmol/L; *P*<0.001), and lower left ventricular ejection fraction (41.12±5.51% versus 43.34±6.69%; *P*=0.010) (Table 3).

Table 4 presents the results of a linear regression analysis of factors associated with corrected QT interval prolongation in patients presenting with ST-elevation myocardial infarction (STEMI). Age showed a significant positive association with QT interval prolongation ($\beta = 0.396$, $P < 0.001$), indicating that increasing age was associated with greater QT

Table 1: Baseline demographic and clinical characteristics of the study population (N=296)

Variable	Subgroup	Frequency (%)
Age group	Young adults	148 (50.0%)
	Middle-aged adults	148 (50.0%)
Sex	Male	242 (81.8%)
	Female	54 (18.2%)
Hypertension	Yes	119 (40.2%)
	No	177 (59.8%)
Diabetes mellitus	Yes	70 (23.6%)
	No	226 (76.4%)
Smoking	Yes	129 (43.6%)
	No	167 (56.4%)
Site of infarction	Anterior	152 (51.4%)
	Inferior	100 (33.8%)
	Lateral	30 (10.1%)
	Other/Extensive	14 (4.7%)
Corrected QT interval prolongation	Present	75 (25.3%)
	Absent	221 (74.7%)
		Median (IQR)
Age (years)	Overall	45.5 (38.0-58.0)
		Mean±SD
Heart rate (beats/min)	Overall	84.14±10.60
Serum potassium (mmol/L)	Overall	4.05±0.24
Left ventricular ejection fraction (%)	Overall	42.78±6.48
Corrected QT interval (ms)	Overall	442.51±15.32

QTc = Corrected QT interval; SD = Standard deviation

Table 2: Comparison of corrected QT interval and corrected QT interval prolongation between young and middle-aged adults (N=296)

Variable	Subgroup	Young adults (N=148)	Middle-aged adults (N=148)	χ^2 value	*P*-value
		Mean±SD			
Corrected QT interval (ms)		436.84±13.91	448.17±14.59	-	<0.001
		Frequency (%)			
Corrected QT interval prolongation	Present	26 (17.6%)	49 (33.1%)	9.447	0.002
	Absent	122 (82.4%)	99 (66.9%)		

QT = QT interval; SD = Standard deviation; χ^2= Chi Square value

prolongation. Age explained 15.7% of the variation in QT interval prolongation ($R^2 = 0.157$).

Heart rate was also significantly and positively associated with QT interval prolongation (β = 0.499, P < 0.001), indicating that patients with higher heart rates had greater QT interval prolongation. The model explained 24.7% of the variability in QT prolongation ($R^2 = 0.247$).

Serum potassium level demonstrated a significant negative association with corrected QT interval prolongation (β = -0.324, *P* < 0.001), indicating that lower potassium levels were associated with increased QT interval prolongation. Serum potassium accounted for 10.5% of the variation in QT

Table 3: Association of corrected QT interval prolongation with demographic and cardiovascular risk factors (N = 296)

Variable	Subgroup	QTc absent (N=221)	QTc present (N=75)	χ^2 value	*P*-value
		Frequency (%)			
Sex	Male	176 (79.6%)	66 (88.0%)	2.625	0.105
	Female	45 (20.4%)	9 (12.0%)		
Hypertension	Yes	89 (40.3%)	30 (40.0%)	0.002	0.967
	No	132 (59.7%)	45 (60.0%)		
Diabetes mellitus	Yes	46 (20.8%)	24 (32.0%)	3.880	0.049
	No	175 (79.2%)	51 (68.0%)		
Smoking	Yes	90 (40.7%)	39 (52.0%)	2.896	0.089
	No	131 (59.3%)	36 (48.0%)		
Site of infarction	Anterior	102 (46.2%)	50 (66.7%)	10.555	0.014
	Inferior	81 (36.7%)	19 (25.3%)		
	Lateral	27 (12.2%)	3 (4.0%)		
	Other/Extensive	11 (5.0%)	3 (4.0%)		
		Median (IQR)		-	
Age (years)		44 (37-57)	56 (42-61)		<0.001
		Mean±SD			
Heart rate (beats/min)		81.95±10.38	90.59±8.42	-	<0.001
Serum potassium (mmol/L)		4.08±0.23	3.94±0.23		<0.001
Left ventricular ejection fraction (%)		43.34±6.69	41.12±5.51		0.010

QTc = Corrected QT interval, SD = Standard deviation; χ^2= Chi Square value

Table 4: Linear Regression Analysis of Corrected QT Interval Prolongation in Patients Presenting with ST-Elevation Myocardial Infarction (N = 296)

Variables	Study Parameter Median (IQR)	Beta	Std.Error	*t*-value	R^2	*P*-value
Age (years)	45.5 (38.0- 58.0)	0.396	0.076	7.403	0.157	<0.001
	Mean ± SD					
Heart Rate (bpm)	84.14 ± 10.60	0.499	0.073	9.883	0.247	<0.001
Serum Potassium (mmol/L)	4.05 ± 0.24	-0.324	3.550	-5.872	0.105	<0.001
LVEF (%)	42.78 ± 6.48	-0.295	0.132	-5.288	0.87	0.005

SD = Standard Deviation; bpm = Beats Per Minute; mmol/L = Millimoles per Liter; LVEF = Left Ventricular Ejection Fraction

prolongation ($R^2 = 0.105$).

Similarly, left ventricular ejection fraction (LVEF) showed a significant negative association with QT interval prolongation (β = -0.295, *P* = 0.005), suggesting that reduced LVEF was associated with greater QT prolongation in STEMI patients. LVEF explained 8.7% of the variability in corrected QT interval prolongation ($R^2 = 0.087$).

Discussion

In this study, corrected QT interval prolongation was present in 25.3% of patients with first-time ST-elevation myocardial infarction and was significantly more common in middle-aged adults than in young adults. The mean corrected QT interval was also significantly higher in the middle-aged group. These findings are consistent with the available ST-elevation myocardial infarction literature. Mann et al reported prolonged QT on admission in 217 of 1,054 patients with ST-elevation myocardial infarction (26%), which is very close to the prevalence observed in our cohort.[11] The similarity supports the clinical plausibility of our findings and suggests that corrected QT interval prolongation is a frequent electrophysiological abnormality during acute infarction.

Middle-aged adults in our study had a less favorable risk-factor profile than young adults, with higher frequencies of hypertension and diabetes mellitus, whereas smoking was more common in younger patients. Alexander et al observed a similar pattern,

reporting smoking more frequently in younger ST-elevation myocardial infarction patients, while hypertension and diabetes mellitus were more common in older patients.[12] Liang et al also showed that younger patients were more often male and smokers, whereas older patients had a greater burden of conventional cardiovascular risk factors.[13] These findings suggest that middle-aged patients may have a greater burden of metabolic and structural disease, which could contribute to more pronounced repolarization abnormalities during infarction.

Prolongation of the QT interval was significantly associated with diabetes mellitus in our study. This is medically plausible because diabetes mellitus is associated with autonomic dysfunction, endothelial injury, oxidative stress, and myocardial ion-channel remodeling, all of which may amplify ischemia-induced delay in ventricular repolarization.[14] Mata Marín and colleagues found dysglycaemia in 44% of young ST-elevation myocardial infarction patients and showed that diabetes mellitus was associated with more advanced coronary artery disease.[15] Migisha R et al. likewise reported prolonged corrected QT interval among adults with diabetes mellitus even outside the acute infarction setting.[16] These observations support the view that diabetes mellitus lowers repolarization reserve and may predispose patients with ST-elevation myocardial infarction to corrected QT interval prolongation.

The highest frequency of corrected QT interval prolongation in our study was observed in anterior infarction. This is clinically logical because anterior infarction usually reflects a larger ischemic territory and greater myocardial jeopardy. Coskun A et al. demonstrated markedly prolonged corrected QT interval values in high-risk acute coronary syndrome phenotypes, reinforcing the link between more severe ischemic presentation and longer corrected QT interval.[17] Similarly, Bendary A et al. showed in anterior ST-elevation myocardial infarction that repolarization-related electrocardiographic markers predicted early ventricular arrhythmias and arrhythmic death.[18] Our finding, therefore, supports the concept that corrected QT interval prolongation may serve as a marker of greater electrical instability in larger infarcts.

Patients with a prolonged corrected QT interval in our cohort were older and had higher heart rate, lower potassium levels, and lower left ventricular ejection fraction. These associations are biologically coherent. Lower serum potassium levels weaken repolarizing currents and favor corrected QT interval prolongation; Kildegaard H et al. reported frequent electrocardiographic abnormalities, including prolonged corrected QT intervals, among patients with hypokalemia.[19] Higher heart rate may reflect stronger sympathetic activation, while lower left ventricular ejection fraction likely indicates larger infarct burden and greater ventricular dysfunction. Doğan M et al. also reported an inverse relationship between corrected QT interval and left ventricular ejection fraction after ST-elevation myocardial infarction.[20]

Corrected QT interval prolongation was not significantly associated with sex, hypertension, or smoking in our study. During the acute phase of infarction, the immediate corrected QT interval response may be influenced more strongly by infarct size, autonomic activation, electrolyte balance, and ventricular function than by chronic risk factors alone. A major strength of this study is the focused comparison of two clinically relevant adult age groups in a cohort of first-time ST-elevation myocardial infarction patients using routinely available bedside and laboratory measures. The study is limited by its single-center design, cross-sectional analysis, and the absence of follow-up data for ventricular arrhythmias, mortality, and long-term clinical outcomes. Therefore, causal inferences and broader prognostic generalizations should be made cautiously. Future multicenter studies with longitudinal follow-up should determine whether age-related prolongation of the corrected QT interval translates into differences in arrhythmic and survival outcomes.

Conclusion

Corrected QT interval prolongation was common in patients with first-time ST-elevation myocardial infarction and was significantly more frequent in middle-aged adults than in young adults. These study findings suggest that corrected QT interval prolongation may serve as a practical marker of increased clinical and electrophysiological risk in acute infarction, particularly among middle-aged patients and those with adverse metabolic, infarct-

related, and hemodynamic characteristics.

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Author Contributions

AK: Conception, design of the work, and approval for final submission
MS: Manuscript writing for methodology design, investigation, and approval for final submission
WR: Revising, editing, supervising for intellectual content, and approval for final submission
SS: Writing the original draft, proofreading, and approval for final submission
RH: Validation of data, interpretation, write-up of results, and approval for final submission
TZ: Data acquisition, curation, statistical analysis, and approval for final submission
AK is the nominated guarantor and takes full responsibility for the overall content and integrity of the work