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Original Article

Comparison of QT Dispersion Alterations and Left Ventricular Systolic Function in Acute ST-Elevation Myocardial Infarction Following Revascularization by Thrombolytic Therapy versus Primary PCI

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ABSTRACT

Background: Limited information exists regarding alterations in QT dispersion (QTd) in patients with acute ST-elevation myocardial infarction (STEMI) following thrombolytic therapy compared to primary percutaneous coronary intervention (PCI). Speckle-tracking echocardiography (STE) has emerged as a crucial prognostic tool in recent STEMI cases, allowing for the assessment of global and regional remodeling. We sought to analyze the changes in the QTd interval and global longitudinal strain (GLS) in STEMI patients after early reperfusion.

Methods: This study is a prospective observational analysis involving 100 STEMI patients. The participants were divided into 2 groups: Group I, consisting of 55 patients treated with primary PCI, and Group II, composed of 45 patients treated with thrombolytic therapy. A 12-lead surface ECG was performed upon admission and 48 hours post-revascularization to assess QTd changes in patients receiving thrombolytic therapy versus those undergoing primary PCI. GLS was evaluated using STE 72 hours after revascularization.

Results: No differences were observed between the 2 groups concerning baseline characteristics. A significant reduction in QTd occurred after revascularization in both groups, with a greater mean reduction noted in the primary PCI group. Patients in the primary PCI group exhibited significantly more negative GLS values than those in the thrombolytic group. Admission QTd and the percentage of QTd reduction were significant predictors of ventricular tachycardia.

Conclusions: This study underscores the potential of primary PCI to enhance patient outcomes in STEMI. The superior GLS results, reduced incidence of ventricular arrhythmias, and QTd reduction following revascularization in STEMI patients indicate that primary PCI could significantly transform patient care. ***(Iranian Heart Journal 2025; 26(3): 27-40)***

KEYWORDS: QT dispersion, Global longitudinal strain, Primary PCI, Acute ST-elevation myocardial infarction, Thrombolytic therapy

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Approximately 50% of deaths resulting from acute myocardial infarction (AMI) occur within 1 hour of the event. The primary cause of mortality is arrhythmias, while later causes of death include electromechanical dissociation, cardiogenic shock, and cardiac rupture. Several researchers suggest that a patient's prognosis following AMI is influenced by variations in the level and type of autonomic control over the heart. [1, 2]
The association between the likelihood of lethal arrhythmias and increased sympathetic activity or decreased vagal tone has led to the development of quantitative and qualitative markers of autonomic activity. QT dispersion (QTd) is recognized as a marker of autonomic heart tone. QTd reflects variations in local myocardial repolarization and the electrophysiological environment. The clinical significance of QTd stems from the understanding that regional heterogeneity in the action potentials of adjacent cardiac muscle tissue can initiate and sustain ventricular arrhythmias, particularly in vulnerable myocardium. [3, 4]

QTd has been shown to decrease following successful coronary artery revascularization. Nonetheless, there is limited information regarding the analysis of QTd changes in patients with acute ST-elevation myocardial infarction (STEMI) undergoing thrombolytic therapy compared to those receiving primary percutaneous coronary intervention (PCI). Speckle-tracking echocardiography (STE) allows for the tracking of speckles in 2D images in an angle-independent manner, enabling the assessment of their movement (strain) throughout the cardiac cycle. In recent cases of STEMI, left ventricular (LV) remodeling has emerged as one of the most critical prognostic factors. [5] STE is an advanced, noninvasive imaging modality that allows for rapid and accurate assessment of the global and regional functions of atrial and ventricular chambers, including the evaluation of chamber remodeling. This technique operates independently of the angle of insonation and in-plane translational motion. [6]

Objectives

In the present study, we primarily aimed to analyze alterations in the QTd interval and global longitudinal strain (GLS) in patients with STEMI following early reperfusion, comparing outcomes between thrombolytic therapy and primary PCI. Further, we sought to evaluate the influence of risk factors on QTd and GLS in patients with AMI after reperfusion treatment.

METHODS

The Research Ethics Committee of the Faculty of Medicine at Beni-Suef University approved the protocol during its meeting on July 15, 2018, in accordance with the Declaration of Helsinki guidelines. This approval is recorded under the Federal Wide Assurance (FWA) for the Safety of Human Subjects (Approval FWA00015574). All patients provided informed written consent. The current study is a carefully conducted prospective observational study involving 100 patients with acute STEMI, following the application of the exclusion criteria outlined in Figure 1.
Patients were recruited from Beni-Suef University Hospital and Sohag Health Insurance Hospital (Alhilal) between August 2018 and February 2020. They were divided into 2 groups based on the inclusion criteria for management according to the ESC 2018 guidelines, as follows: Group I: 55 patients treated with primary PCI, and Group II: 45 patients treated with thrombolytic therapy.
The selection of a reperfusion strategy was determined by the approximate time from STEMI diagnosis to PCI-mediated reperfusion (wire crossing), in accordance

with the ESC Guidelines on Myocardial Revascularization 2018. Primary PCI was the preferred reperfusion strategy if the time from STEMI diagnosis to wire crossing was less than 60 minutes (for patients presenting at a PCI-capable hospital) or less than 90 minutes (for patients who could be transferred to a PCI-capable hospital). Otherwise, thrombolytic therapy was the preferred approach. Patients presenting more than 120 minutes after the onset of chest pain were excluded from the study. [7]

All patients underwent the following assessments: detailed history-taking and clinical examination, with particular attention to risk factors such as chest pain onset, hemodynamic instability, and in-hospital complications. Laboratory investigations were performed upon admission and repeated daily as clinically indicated. Standard 12-lead surface ECGs were obtained on admission and 48 hours post-revascularization to evaluate QTd changes, comparing thrombolytic therapy recipients with primary PCI patients. QT intervals were measured from QRS complex onset to T-wave termination. For each tracing, we recorded the maximum and minimum QT interval values.

Heart rate-corrected QT intervals (QTc) were calculated using Bazett's formula ($QTc = QT/\sqrt{RR}$).

QTd was defined as the difference between the maximum and minimum QT interval values across leads, measured in milliseconds (ms). [8] Echocardiographic assessment of GLS was performed 72 hours post-revascularization using 2D STE. GLS measurements were obtained from apical 4-, 2-, and 3-chamber views. The operator verified the software's ventricular motion tracking accuracy and manually adjusted any suboptimal tracking segments. To ensure blinded analysis, we recorded initial GLS measurements during standard patient appointments and then deleted them from the system before subsequent re-measurements. [9]

Inclusion and Exclusion Criteria

The study included 143 patients with STEMI, of whom 43 were excluded based on specific criteria. Exclusions were made for 22 patients who underwent an early pharmacoinvasive strategy within 72 hours, 16 patients who presented late, and 5 patients who experienced electrolyte disturbances. The decision to delay the pharmacoinvasive strategy beyond 72 hours was influenced by logistical challenges, financial constraints, insurance coverage issues, and refund policies, which allowed the study to proceed. Exclusion criteria included a history of previous or acute atrial fibrillation, intraventricular conduction disorders, complete heart block, and patients with paced ventricles. In addition, individuals with a history of LV dysfunction, chronic use of certain medications (e.g., digitalis, antiarrhythmics, antidepressants, and antipsychotics), electrolyte disturbances, and those who presented 120 minutes or more after the onset of chest pain were also excluded. Furthermore, patients who had failed thrombolytic therapy and those planned for a pharmacoinvasive strategy within 72 hours of the study were not included.

Statistical Analysis

Data analysis was conducted using SPSS version 25 (Statistical Package for the Social Sciences) for Windows. The sample size and power analysis were determined using G*Power software version 3.1.9.4. We calculated the sample size criteria with a 95% confidence level and 80% study power for various variables, resulting in a required sample size of 100 patients. The statistical significance cutoff value was set at 0.05. Intra- and interobserver variabilities for echocardiographic parameters were assessed by randomly selecting 25 patients and repeating the study on the same cine loop,

either by the same operator or independently by 2 different operators. Intraclass correlation coefficients were employed to evaluate reliability, with values less than 0.5 indicating poor reliability, between 0.5 and 0.75 signifying moderate reliability, between 0.75 and 0.9 denoting good reliability, and above 0.9 representing excellent reliability.

RESULTS

Baseline characteristics showed no significant differences between the primary PCI and thrombolytic therapy groups in age (P = 0.458, t-test), sex (P = 0.342, chi-square), or body mass index (P = 0.053, t-test). Comorbidity distributions were similarly comparable for diabetes mellitus (P = 0.121), hypertension (P = 0.098), dyslipidemia (P = 0.854), family history (P = 0.875), and smoking status (P = 0.955), all analyzed using the chi-square test. The 2 groups also demonstrated comparable STEMI distributions (P = 0.118, chi-square) and baseline QTd values (P = 0.053). Nevertheless, at 48-hour follow-up, the thrombolytic therapy group exhibited significantly greater QTd and less negative global longitudinal strain values (apical 2-, 3, and 4-chamber views) than the PCI group (Table 1).

Both revascularization strategies demonstrated significant QTd reduction (P < 0.001), though the primary PCI group showed a markedly greater mean reduction than thrombolytic therapy (Table 2). This intergroup difference was analyzed using the Mann-Whitney U test. Consistent with these findings, Table 3 reveals that the percentage reduction in QTd was significantly more pronounced in PCI-treated patients than in those receiving thrombolytics.

Table 1. QTd and GLS in the 2 study groups

Parameters	Group I N=55 no.(%)	Group II N=45 no.(%)	*P*-value
QTd on admission Mean±SD Range (min-max) Median	138.7±12 (118-154) 138	140.7±18 (125-164) 146	0.053
QTd at 48 h Mean±SD Range (min-max) Median	87.2±10.3 71-107 86	125.1±15.2 101- 175 123	<0.001**
AP3 longitudinal strain Mean±SD Range (min-max) Median	-18.7%±4.2% -30.2% to-10.6% -18.2%	-10.9%±3.4% -21.7% to -2.30% -11.9%	<0.001**
AP4 longitudinal strain Mean±SD Range (min-max) Median	-18.4%±3.3% -24.6% to -10.5% -18.4%	-11.6%±2.9% -17.4% to -1.5% -11.2%	<0.001**
AP2 longitudinal strain Mean±SD Range (min-max) Median	-18.4% ±3.8% (-24.6% to-8.5%) -19.4%	-11.5% ±2.8% (-16.9% to -2.6%) -11.8%	<0.001**
Global longitudinal strain Mean±SD Range (min-max) Median	-18.4%±2.9% -23.1% to -13.5% -17.5%	-11.4%±2.3% -15.5% to -2.8% -11.7%	<0.001**

QTd: QT dispersion, PCI: percutaneous coronary intervention, AP4: apical 4-chamber, AP3: apical 3-chamber, AP2: apical 2-chamber
All the parameters mentioned were compared using the Mann-Whitney U test.

Table 2. Follow-up of QT dispersion in both groups

Parameters Mean±SD		Primary PCI N=55 no.(%)	Thrombolytic Therapy N=45 no.(%)	*P*-value (between the mean differences in the 2 groups)
On admission		138.7± 8.8	144.6±7.3	<0.001**
At 48 h		87.1± 10.2	125.1± 15.2	
P-value (pre-post in each group)	Mean difference	51.5±8.2	19.5±10.8	
		<0.001**	<0.001**	

PCI: percutaneous coronary intervention

Pre-post measures were compared using the Wilcoxon signed-rank test.

Table 3. Comparison of the QT dispersion reduction percentage between the 2 revascularization strategies

% of QT dispersion reduction	Primary PCI N=55 (%)	Thrombolytic Therapy N=45 (%)	*P*-value
Mean± SD Range (min-max) Median	37.2% ±5.7% (23.5%-47.8%) 37.3%	14.1% ±6.9% (2%-28.2%) 14.3%	<0.001**

PCI: percutaneous coronary intervention

The Mann-Whitney *U* test was used.

Patients with anterior, inferior, and inferolateral STEMI in the primary PCI group exhibited a significantly greater reduction in QTd (from baseline to 48 hours after the intervention) than those in the thrombolytic therapy group. While the percentage of QTd reduction was similar across different types of STEMI in the primary PCI group, patients with lateral and inferior STEMI in the thrombolytic group demonstrated a higher percentage of QTd reduction than those with anterior and inferolateral STEMI (Table 4).

Table 5 shows that patients with anterior, inferior, and inferolateral STEMI in the primary PCI group demonstrated significantly more negative GLS values than those in the thrombolytic therapy group.

No significant differences existed between patients who developed ventricular tachycardia (VT) in the primary PCI group and the thrombolytic therapy group concerning their QTd on admission (P = 0.999).

The percentage of QTd reduction after 48 hours was statistically significantly higher in the primary PCI group than in the thrombolytic group (P = 0.002 and P < 0.001, respectively). In the primary PCI group, patients who developed VT had significantly higher QTd on admission than those who did not develop VT (P = 0.036). Still, the percentage of QTd reduction 48 hours after PCI was not statistically significant for either patients with VT or those without (P = 0.473). Moreover, the percentage of QTd reduction 48 hours after thrombolytic therapy was statistically significantly higher in patients without VT than in those with VT (P < 0.001) (Table 6 & Figure 2).

Table 4. Comparison between different sites of STEMI in the 2 study groups regarding the percentage of QT dispersion reduction

% of QT Dispersion Reduction	Primary PCI N=55 (%)	Thrombolytic Therapy N=45 (%)	*P*-value
Anterior	37.3%±4.03a	11.2%±6.2a	<0.001**
Lateral	34.8%±11.1a	19.2%b	0.352
Inferior	37.6%±6.3a	18.4%±6.5b	<0.001*
Inferolateral	28.6%a	10.4%±4.4a	0.012*
P-value in the same group	0.412a	0.004*	

PCI: percutaneous coronary intervention, STEMI: ST-elevation myocardial infarction

Different letters denote significant differences between STEMI in the same group. The 2 study groups were compared using the Mann-Whitney *U* test. The different sites of STEMI were compared using the Kruskal-Wallis test.

Table 5. Comparison between different sites of STEMI in the 2 study groups regarding global longitudinal strain

Global Longitudinal Strain	Primary PCI N=55 (%)	Thrombolytic Therapy N=45 (%)	*P*-value
Anterior	-17.4%±2.8%	-10.4%±2.7%	<0.001**
Lateral	-18.6%±3.2%	-14.2%±-----	0.345
Inferior	-19.1%±2.9%	-12.1%±1.45%	<0.001*
Inferolateral	-16.2%±----	-11.9%±1.9%	0.097
	0.175	0.084	

PCI: percutaneous coronary intervention, STEMI: ST-elevation myocardial infarction

The evaluation of groups was completed using the Mann-Whitney *U* test. Comparisons between different sites of STEMI were done using the Kruskal-Wallis test.

Table 6. Comparison between the primary PCI and thrombolytic therapy groups regarding QTd in patients with the incidence of VT and patients without the incidence of VT

QTd (MW)	Primary PCI		Thrombolytic Therapy		*P*-value
	No VT I (no=54)	VT II (no=1)	No VT I (no=39)	VT II (no=6)	
On admission	138.4±8.7	154.000	142.9±5.9	156.2±5.1	PI(non)=0.016* PII(VT)=0.999
	P-value no vs. yes=0.036*		P-value no vs. yes<0.001*		
Percentage of reduction	37.3±5.7	32.5±.	15.4±6.3	2.5±5 (median=3.5)	PI<0.001* PII=0.002*
	P-value no vs. yes=0.473		P-value no vs. yes<0.001*		

QTd: QT dispersion, PCI: percutaneous coronary intervention, MW: Mann-Whitney *U* test, VT: ventricular tachycardia

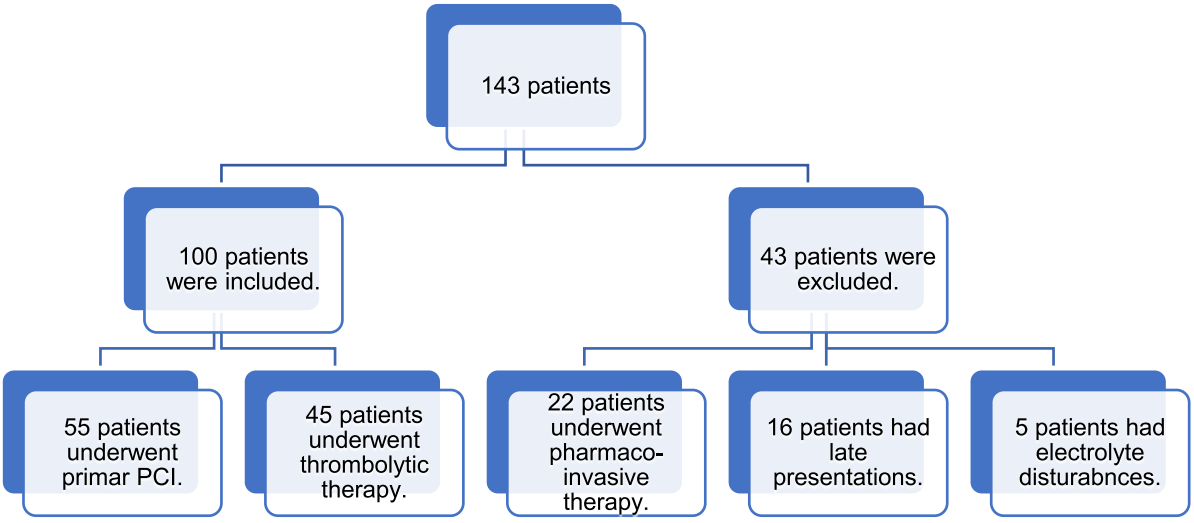

Figure 1. The image showcases the study flow chart.
PCI: percutaneous coronary intervention

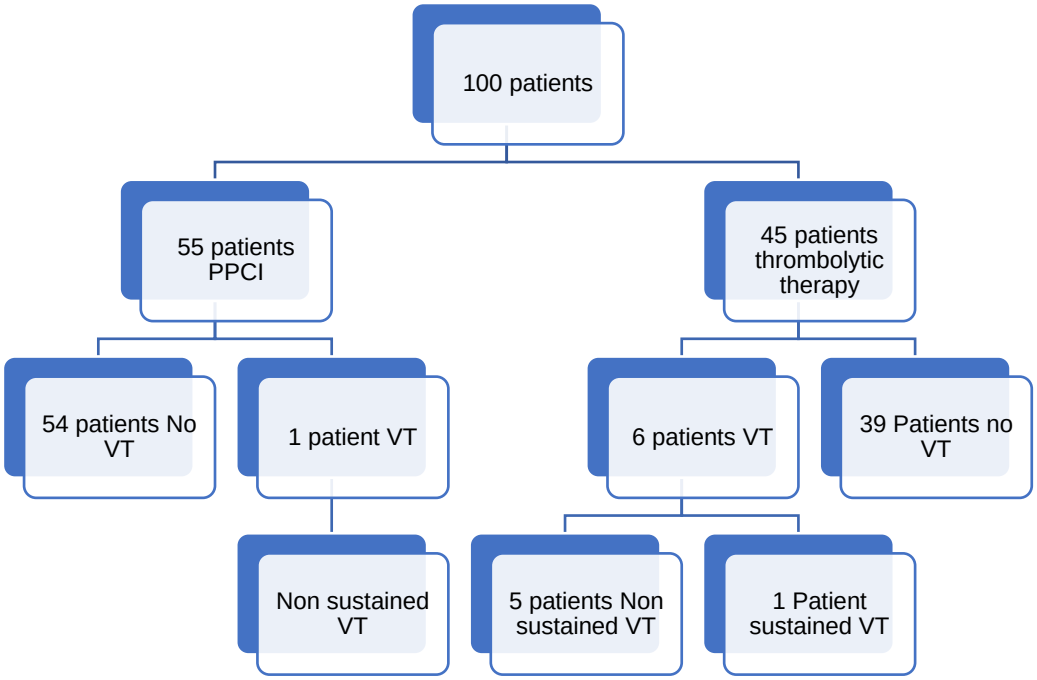

Figure 2. The image illustrates comparisons between the primary PCI and thrombolytic therapy groups regarding the incidence of VT.
PCI: percutaneous coronary intervention, VT: ventricular tachycardia

Both admission QTd (cutoff > 152 ms) and QTd reduction percentage (cutoff ≤ 7.7%) significantly predicted VT occurrence across all interventions, with admission values showing 85.71% sensitivity, 97.85% specificity, 75% positive predictive value (PPV), and 98.9% negative predictive value (NPV). Post-intervention reduction demonstrated 85.71% sensitivity, 94.62%

specificity, 54.5% PPV, and 98.9% NPV (Figures 3-4 & Table 7).

In the thrombolytic group specifically, an admission QTd value exceeding 152 milliseconds predicted VT with 83.33% sensitivity, 97.44% specificity, 83.3% PPV, and 97.4% NPV, while a QTd reduction of 6.3% or less post-thrombolysis showed 83.33% sensitivity, 87.18% specificity, 50% PPV, and 97.1% NPV (Figures 5-6 & Table 8).

Predictive values for QTd parameters in the primary PCI group were not calculated due to only 1 VT case occurrence.

Table 7. Predictive performance of admission QT dispersion and 48-hour reduction for VT occurrence (all interventions; N=100)

Items	QT Dispersion on Admission	Percentage of QT Dispersion Reduction
AUC	0.984	0.911
P-value	<0.001*	<0.001*
Cut-off	>152 msec.	≤7.7 %
Sensitivity (95% CI)	85.71 (42.1 - 99.6)	85.71 (42.1 - 99.6)
Specificity (95% CI)	97.85 (92.4 - 99.7)	94.62 (87.9 - 98.2)
PPV (95% CI)	75.0 (42.4 - 92.4)	54.5 (32.7 - 74.8)
NPV (95% CI)	98.9 (93.7 - 99.8)	98.9 (93.5 - 99.8)

VT: ventricular tachycardia, AUC: area under the curve, PPV: positive predictive value, NPV: negative predictive value

The ROC curve detected the optimal cutoff.

Table 8. Predictive performance of QT dispersion Parameters for VT following thrombolysis (N=45)

items	QT Dispersion on Admission	Percentage of QT Dispersion Reduction
AUC	0.983	0.970
P-value	<0.001*	<0.001*
Cutoff	>152 msec.	≤6.3 %
Sensitivity (95% CI)	83.33 (35.9 - 99.6)	83.33 (35.9 - 99.6)
Specificity (95% CI)	97.44 (86.5 - 99.9)	87.18 (72.6 - 95.7)
PPV (95% CI)	83.3 (41.1 - 97.3)	50.0 (29.0 - 71.0)
NPV (95% CI)	97.4 (86.4 - 99.6)	97.1 (85.0 - 99.5)

VT: ventricular tachycardia, AUC: area under the curve, PPV: positive predictive value, NPV: negative predictive value

The ROC curve detected the optimal cutoff.

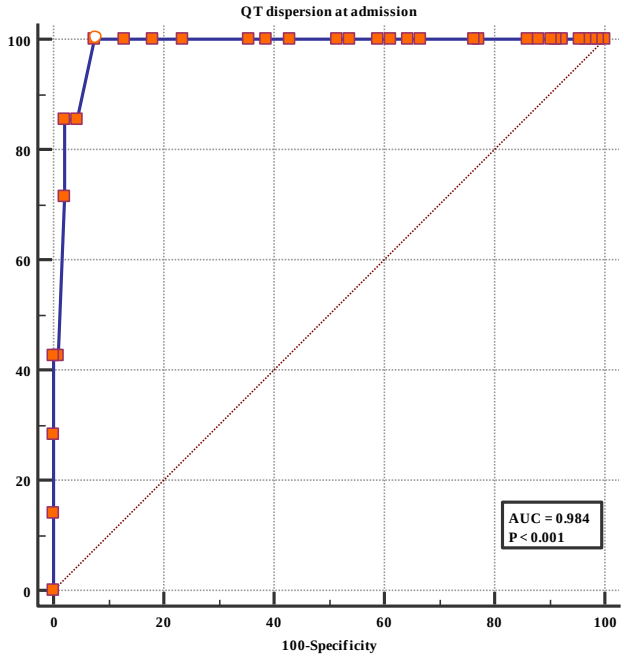

Figure 3. The image presents the receiver operating characteristic (ROC) curve analysis of admission QT dispersion for VT prediction across all interventions.
VT: ventricular tachycardia

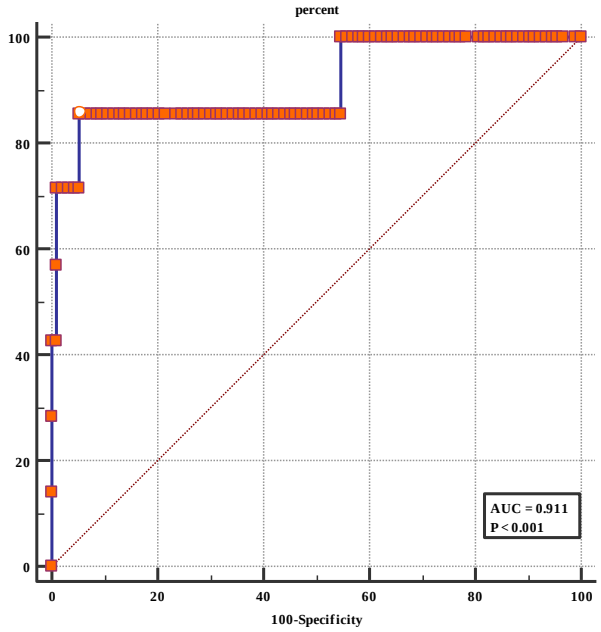

Figure 4. The image presents the receiver operating characteristic (ROC) analysis of QT dispersion reduction percentage for VT prediction across all interventions.
VT: ventricular tachycardia

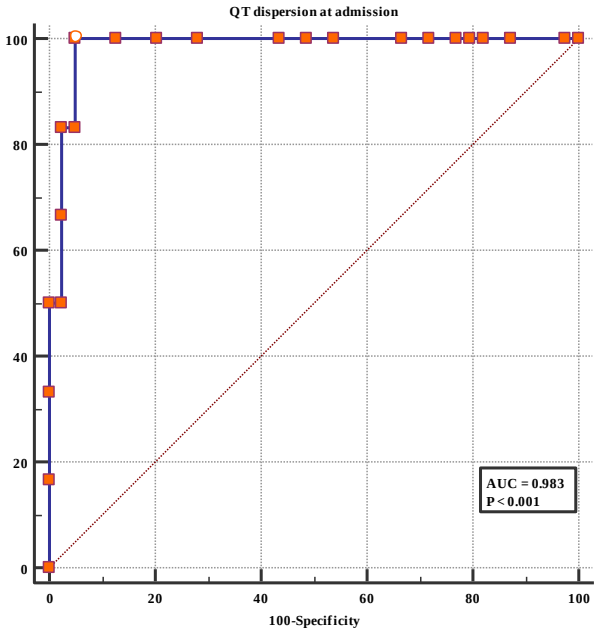

Figure 5. The image shows the receiver operating characteristic (ROC) analysis of admission QT dispersion for VT prediction in thrombolysis-treated patients.
VT: ventricular tachycardia

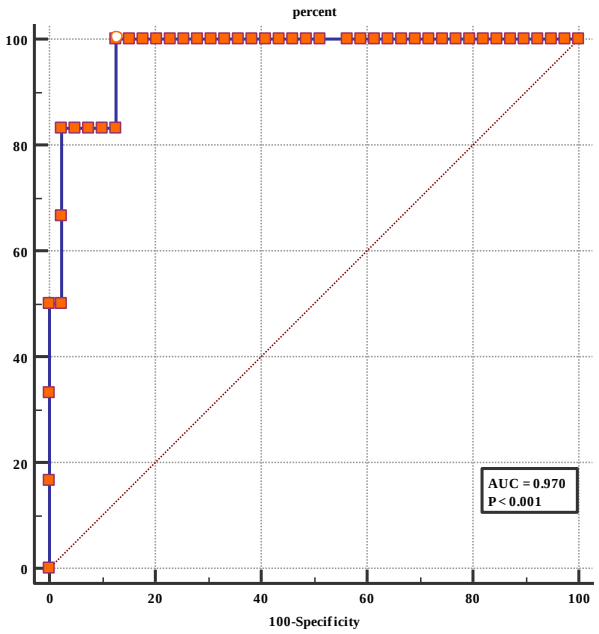

Figure 6. The image showcases the receiver operating characteristic (ROC) analysis of QT dispersion reduction for VT prediction following thrombolysis.

VT: ventricular tachycardia

DISCUSSION

Our study found no statistically significant difference in admission QTd between the primary PCI and thrombolytic groups. Nonetheless, thrombolysis-treated patients demonstrated significantly higher QTd at 48 hours post-reperfusion ($P \leq 0.001$). We quantified this change using the percentage reduction in QTd between admission and 48-hour post-revascularization ECGs.

Both groups showed significant QTd reduction after revascularization ($P < 0.001$), although the mean reduction was greater in the PCI group. These findings align with Ornek et al., [11] who reported substantial QTd reduction during the first week post-MI, but contrast with Heris et al., [11] who observed no significant thrombolysis effect on QTd.

Patients treated with primary PCI showed a significantly greater QTd reduction (37.2% ± 5.7%) than those treated with thrombolytic therapy (14.1% ± 6.9%; $P < 0.001$). These findings agree with Babapour et al., [12] who reported decreased QTd 24 hours post-PCI, and Hamza et al., [12] who demonstrated effective QTc and QTd reduction within 24 hours of successful primary PCI.

No significant difference existed in admission QTd between VT patients in the PCI versus thrombolytic groups ($P = 0.999$). Still, VT patients undergoing PCI had significantly greater 48-hour QTd reduction than those receiving thrombolysis ($P = 0.002$ and $P < 0.001$, respectively).

In the primary PCI group, VT patients exhibited significantly higher admission QTd than non-VT patients ($P = 0.036$). Nevertheless, the percentage of QTd reduction at 48 hours post-PCI showed no significant difference between VT and non-VT patients ($P = 0.473$), reflecting comparable QTd reduction regardless of VT occurrence.

These findings indicate that ischemia-induced QT prolongation represents a significant arrhythmogenic factor that responds to successful PCI. The 48-hour QTd reduction may serve as a marker of effective PCI, potentially related to higher thrombolysis in myocardial infarction (TIMI) flow grade III rates achieved through PCI. These results chime with those in a study by Shahir et al., [13] who reported greater QT/QTc dispersion reduction with primary PCI versus thrombolysis, correlating with reduced ventricular arrhythmia incidence.

Pan et al. [14] demonstrated that post-PCI QTc dispersion reduction independently predicted major cardiovascular events (life-threatening arrhythmias, nonfatal MI, heart failure hospitalization, and death) at 1-year follow-up. Their analysis revealed that each 10-millisecond QTc dispersion decrease corresponded to a 49.8% lower cardiovascular risk.

In the thrombolytic group, inferior/lateral infarction patients showed significantly greater QTd reduction (18.4% ± 6.5% and 19.2%, respectively) than anterior/inferolateral STEMI patients (11.2% ± 6.2% and 10.4% ± 4.4%; $P = 0.004$). However, in November 2020, a study by Valizadeh et al., [15] comparing streptokinase and PCI, found no significant QTd changes relative to MI location. These findings are concordant with those in a study by George et al., [16] who reported insignificant QT/QTc dispersion variations between anterior and inferior MI locations.

Cavusoglu et al. [17] and Hassan [18] reported higher admission QT/QTc dispersion values in anterior versus inferior MI patients based on initial ECGs. Contrary to our findings, Cavusoglu and colleagues observed significant QT/QTc dispersion reductions post-reperfusion in both infarction locations. These parameters demonstrate infarct-size dependence, with the characteristically larger infarct size in anterior MI likely accounting for its elevated QT/QTc dispersion values. [18]

Primary PCI-treated patients demonstrated significantly more negative GLS values (apical 2-, 3, and 4-chamber views) than thrombolysis-treated patients ($P \leq 0.001$). These findings chime with those in a study by Paul et al., [19] who reported superior LV systolic function (assessed by GLS) in primary PCI versus pharmaco-invasive strategies.

Unlike our observed site-specific differences in QTd reduction, primary PCI-treated patients demonstrated significantly more negative GLS values than thrombolysis-treated patients across all STEMI locations (anterior, inferior, and inferolateral).

The thrombolytic group showed a significant positive correlation between patient age and QTd reduction rate ($r = 0.349$; $P = 0.020$). This contrasts with the results of a study by Mangoni et al., [20] who found age non-predictive of QTd, attributing age-related QT interval increases to myocardial action potential prolongation and cardiac hypertrophy.

Limitations of the Study

1. The relatively small sample size warrants validation through larger-scale studies.
2. Variable symptom-to-ED (emergency department) arrival times prevented ECG standardization, potentially influencing results given the known relationship between ischemic duration and ECG changes.
3. Precise T-wave endpoint determination proved challenging with flat, biphasic, or U-wave-associated T-waves.
4. The absence of established normal GLS reference values represents a notable methodological constraint.
5. While the non-randomized design posed inherent limitations, comparable baseline characteristics between groups helped mitigate selection bias.

CONCLUSIONS

In the current study, primary PCI demonstrated superiority over thrombolytic therapy in patients with AMI, yielding more favorable GLS results and greater QTd reduction at 48 hours post-revascularization. The reduced incidence of serious ventricular arrhythmias following primary angioplasty suggests that its benefits extend beyond epicardial coronary flow restoration, which potentially reflects enhanced myocardial functional recovery. Primary PCI, when logistically feasible, should remain the preferred reperfusion strategy for acute STEMI management.

Declarations

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Authors' Contributions
YA performed coronary angiography and interventions, as well as manuscript editing. HM conducted coronary angiography and interventions, along with manuscript editing. MM was responsible for follow-up and manuscript editing. OA carried out coronary angiography and interventions, echocardiography, statistical analysis, and manuscript editing. All authors have approved the publication and revised the final manuscript.

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Availability of Data and Materials
The data utilized during the study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate
The study protocol was conducted in strict accordance with the Declaration of Helsinki. The Committee of Research and Ethics at Beni-Suef University approved the study protocol in July 2018 (Approval FWA00015574). All patients provided informed written consent to participate, ensuring that the highest ethical standards were upheld.

Consent to Publication
Not applicable.

Conflict of Interest
The authors affirm that they have no competing interests that could potentially influence the outcomes or interpretation of this research. Our sole commitment is to present the findings of this study with the utmost integrity and objectivity.

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