The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 3, 2025

RELATIONSHIP BETWEEN POST-PROCEDURAL FRONTAL QRS-T ANGLE AND TIMI FLOW IN PATIENTS WITH ACUTE STEMI UNDERGOING PPCI

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DOI: https://doi.org/10.5281/zenodo.15142014

Keywords
Fintech, Financial Institutions

Article History
Received on 15 February 2025
Accepted on 15 March 2025
Published on 21 March 2025

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Abstract

Background: *The frontal QRS-T angle has been suggested as a marker of abnormal depolarization and repolarization patterns and has been associated with various cardiovascular outcomes.*

Objective: *Aim of study is to establish relationship between post procedural frontal QRS T angle and TIMI flow in patients with acute STEMI undergoing PPCI.*

Method: *Patients have been divided into 02 groups on the basis of TIMI flow. TIMI (0,1,2) will be labelled as group A and TIMI (3) has been labelled as group B. Post-procedural frontal QRS- T angle has been assessed in both groups.*

Results: *In this study involving 112 patients, normality tests revealed that age (mean 56.21; SD 12.045) and pre QRSTA (mean 82.0485; SD 33.59182) followed a normal distribution. Independent t-tests indicated that age had a significant difference ($p = 0.011$ and 0.009) between patients with slow and normal flow TIMI groups, while pre QRSTA showed a highly significant difference ($p < 0.001$) in both groups. Abnormal distributions were observed for post QRSTA (Median 69.66; Inter Quartile Range 48.87), change in QRS T angle (Median 7.66; Inter Quartile Range 10.95), TIMI flow (Median 0; Inter Quartile Range 2), and post TIMI (Median 3; Inter Quartile Range 1). Mann-Whitney U tests revealed significant differences ($p < 0.001$) between slow and normal flow TIMI groups for these variables. Chi-square tests showed a significant association ($p < 0.001$) between MACE and qualitative variables. Pearson correlation analyses demonstrated a strong negative correlation ($r = -0.740$, $p < 0.01$) between post QRSTA and post TIMI, a significant positive correlation ($r = 0.388$, $p < 0.01$) between post TIMI and change in QRS T angle, a significant negative correlation ($r = -0.410$, $p < 0.01$) between post TIMI and MACE, and a significant negative correlation ($r = -0.365$, $p < 0.001$) between MACE and*

change in QRS T angle.

Conclusion: *Slow flow was associated with higher MACE rates, indicating its clinical relevance. Negative correlations were observed between post QRSTA and post TIMI. MACE also had negative correlations with change in QRS T angle and post TIMI. There was positive correlation between post TIMI and change in QRS T angle.*

INTRODUCTION

Cardiovascular diseases (CVDs) are a leading cause of morbidity and mortality worldwide. Timely diagnosis and management of these diseases are crucial for reducing their burden(Vogel). Timely reperfusion strategies, such as primary percutaneous coronary intervention (PCI) or thrombolytic therapy, are commonly used in the management of STEMI patients(Coughlan and Ibanez, 2023). However, despite successful reperfusion, some patients may still experience adverse outcomes, such as impaired myocardial perfusion or left ventricular dysfunction(Del Buono et al., 2022). PCI can lead to complications such as impaired microvascular perfusion, arrhythmias, and in some cases, a poor prognosis(Rehan et al., 2023). Therefore, there is a need to identify reliable predictors of PCI outcomes to enhance patient risk stratification and guide treatment decisions. The evaluation of post-procedural electrocardiographic (ECG) parameters has been recognized as an important tool for assessing the efficacy of reperfusion in STEMI patients(Andres et al., 2020). The frontal QRS-T angle has been suggested as a marker of abnormal depolarization and repolarization patterns, and has been associated with adverse cardiovascular outcomes in various populations, including patients with acute myocardial infarction(Asarcikli et al., 2022). This angle can be estimated by measuring the difference between QRS axis with T wave axis through 12 lead surface ECG (Kurisu et al., 2018 The hypothesis is that a wider QRS-T angle is associated with impaired microvascular perfusion and reduced myocardial reperfusion, reflected by a lower TIMI flow grade(Dindas et al., 2021). Coronary artery lesions changes the ventricular axis due to ischemia driven myocardial damage (Fajadet et al., 2021). The TIMI flow grade is a widely used angiographic parameter that assesses the degree of coronary blood flow after PCI(Węgiel et al., 2022). It is graded on a scale of 0 to 3, with grade 3 indicating normal blood flow, and grade 0 indicating complete occlusion of the artery(Bauer et al., 2020). A lower TIMI flow grade has been associated with a higher risk of major adverse cardiovascular events (MACE) and mortality in STEMI patients, making it a valuable tool for risk stratification(Magro et al., 2011).Recently, there has been growing interest in the use of the frontal QRS-T angle, a measure of the spatial relationship between the QRS complex and the T wave on the ECG, as a predictor of TIMI flow grade in STEMI patients undergoing PCI(Dindas et al., 2021). Therefore, in this review, we aim to explore the association of post- procedural frontal QRS-T angle with TIMI flow in patients with acute STEMI. Measuring the frontal QRS-T angle is typically done using a 12-lead ECG, which provides a multidimensional view of the heart's electrical activity from different angles. The limb leads (I , III, aVR, aVL, and aVF) and precordial leads (V1 to V6) are used to record the electrical signals from different anatomical positions on the body.measured by two techniques; the one which is known as frontal and the other is spatial. Frontal QRS T can be measured by subtracting the QRS vector with T wave vector to get angle formed between them, but spatial calculation involves Frank leads (X,Y,Z) which are not used in conventional ECG recordings (Choudhuri et al., 2019).

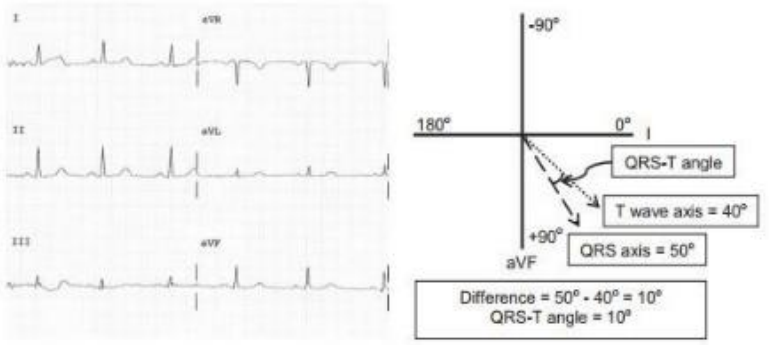
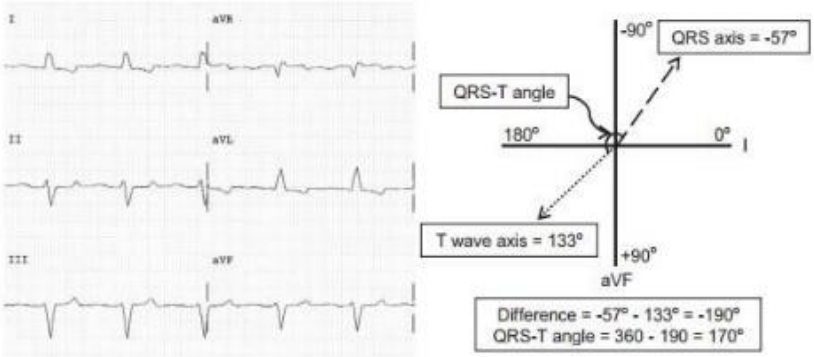
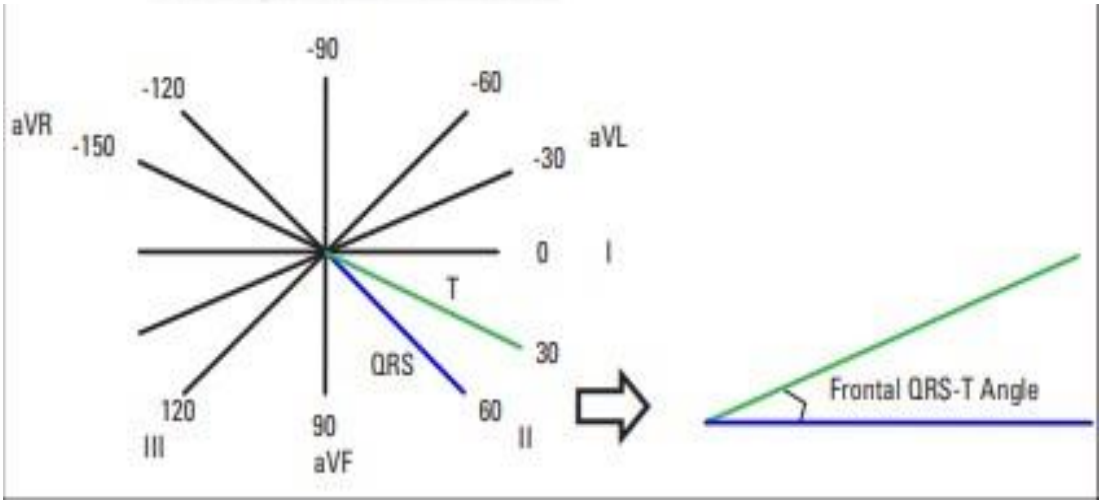


Figure 1. *Electrocardiogram of a subject with a narrow QRS-T angle with a schematic depicting how the QRS-T angle is derived. The QRS axis measures 50° while the T wave axis measures 40° giving a QRS-T angle of 10°.*





AIM AND OBJECTIVES:

Aim of our study is:

1. To determine the relationship between the post procedural Frontal QRS-T angle with the TIMI flow in patients with acute STEMI undergoing PPCI.
2. MACE will be estimated as secondary outcome in both groups. Also, change in pre and post procedural frontal QRS-T angle i.e., ΔQRS-T will also be corelated with TIMI flow as well as MACE as a secondary outcome

METHOD AND MATERIALS:

Study Design:

Observational prospective study.

Setting:

Rawalpindi Institute of Cardiology.(2019-2020)

Duration:

12 months

Sample Size:

The sample size of 112 participants in each group was calculated by the following formula

keeping the power of study equal to 90% and confidence level equal to 95% with expected mean QRS-T angle in group A (TIMI 0,1,2) as 48.0 ± 16.5 and 42.0 ± 10.5 in group B (TIMI 3). (Isik et al., 2021)

Sample Technique: Non probability purposive sampling

- **Sample Selection:**
- **Inclusion criteria:**

1. Patients with Acute STEMI undergoing PPCI

- **Exclusion criteria:**

1. Any prior Hx of MI
2. Any prior Hx of PCI
3. Any hx of CABG
4. Age <18 yrs ; > 80 yrs
5. Any pacing device implanted
6. Underlying bundle branch blocks

METHODOLOGY:

Standard 12 lead surface ECG is performed to each patient presenting to Rawalpindi Institute of Cardiology Emergency Department. ECG is performed using 25 mm/s speed, and 20 mm/mV height. Patients presenting with acute ST elevation Myocardial infarction (STEMI) are selected. Frontal QRS-T angle is calculated from ECG. Frontal QRS-T angle is calculated as follows. Lead I and avF is used for axis calculation. Vectors are graphed on paper as per axis and calculated as follows.

Step 01:

Firstly, vector for QRS is drawn for lead 1 and avF and then resultant QRS vector is obtained.

Step – 02:

Vector for T wave is drawn for lead I, avF and then resultant T wave vector is obtained. Step 03:

Frontal QRS-T angle is obtained by subtracting resultant QRS vector and resultant T wave vector (Macfarlane, 2012).

QRS-T angle is taken as absolute value which will lie between 0 to 180(Zampa et al., 2014b). If the angle is > 180 then it is calculated as absolute value by subtracting from 360(Işık et al., 2021a).

PPCI is performed as per standard protocols via radial and femoral route. Left and right judkins catheters and standard wires is used for angiographic views. Flow is established after procedure.

Flow in coronary arteries is classified as grade 0 (no flow), grade 1 (penetration without perfusion), grade 2 (partial perfusion) or grade 3 (complete perfusion) (Appleby et al., 2000) (**annexure 1**). TIMI Flow is divided into 02 groups. Group A include TIMI (0,1,2) while TIMI

03 flow is included in Group B.(Celik et al., 2014). Post procedural Frontal QRS-T angle is compared between Group A and Group B. Therefore, association between post procedural Frontal QRS-T angle and TIMI flow is established using this methodology.

MACE is included as secondary outcome. Each patient is telephonically called for followed up after 30 days and MACE including myocardial infarction, hospitalization due to heart failure and death, is noted. Also, change in pre and post procedural frontal QRS-T angle i.e., ΔQRS-T is also taken as secondary outcome. It is calculated by subtracting post procedural frontal QRT-T angle from pre procedural frontal QRS-T angle. ΔQRS-T is corelated with TIMI flow as well as MACE and results are devised.

STATISTICAL ANALYSIS:

Data is saved and analyzed using the Statistical Package for Social Sciences (SPSS) v25.0. The numeric data i.e., age and QRS-T angle is presented as mean ± SD (normal distribution) or median and interquartile range (abnormal distribution). The categorical data i.e., gender, pre- morbid and MACE is presented as frequencies and percentages. Normality of the data is assessed by Shapiro-Wilk test. Independent sample t test/ Mann Whitney U test is used to compare the mean age and QRS-T angle between the two groups. Chi square test is used to compare the proportion of gender distribution, premorbid and MACE between both groups. Pearson correlation coefficient test is used to establish relationship between TIMI

flow and QRST angle, TIMI flow and MACE, TIMI flow and change in QRST angle, MACE and change in QRST angle. p-value ≤ 0.05 is considered significant.

RESULTS:

Shapiro-Wilk			
	Statistic	df	Sig.
Age	.991	112	.699
preQRSTA	.979	112	.072
postQRSTA	.971	112	.014
Change in QRS T angle	.889	112	.000
TIMI FLOW	.654	112	.000
postTIMI	.706	112	.000
*. This is a lower bound of the true significance.			
a. Lilliefors Significance Correction			

Chi Square Test				
		TIMIgp		P value
		SLOW FLOW	NORMAL FLOW	
Gender	Male	38(33.9%)	54 (48.2%)	0.263
	Female	11(9.8%)	9 (8.0%)	
MI	AWMI	25(22.3%)	22 (19.6%)	0.204
	IWMI	23(20.5%)	38 (33.9%)	
	LWMI	1(0.9%)	3 (2.7%)	
Coronary artery disease	recanalized/ minor	0(0.0%)	1 (0.9%)	0.019
	SVCAD	9(8.0%)	28 (25.0%)	
	DVCAD	14(12.5%)	16 (14.3%)	
	TVCAD	20(17.9%)	16 (14.3%)	
	CRITICAL LMS	6(5.4%)	2 (1.8%)	
MACE	yes	10(8.9%)	1 (0.9%)	**<0.001**
	no	39(34.8%)	62 (55.4%)	

DISCUSSION:

Among the variables tested, Age showed a Shapiro-Wilk test statistic of .991 (df = 112, Sig. =.699), indicating that it follows a normal distribution. Similarly, pre QRSTA exhibited a test statistic of .979 (df = 112, Sig. = .072), suggesting normality. However, post QRSTA, Change in QRS T angle, TIMI FLOW, and post TIMI displayed test statistics of .971 (Sig. = .014), .889 (Sig. = .000), .654 (Sig. = .000), and .706 (Sig. = .000), respectively. These variables showed significant deviations from normality, as indicated by their low significance levels. The Independent Student's t-test was employed to analyze the age and pre-QRSTA levels. The Mann- Whitney test was used to compare the post-QRSTA levels, change in QRS T angle, TIMI flow, and post TIMI values between the slow flow and normal flow groups. The results of the Independent Student's t-test revealed a statistically significant difference in age between patients with slow flow (M = 59.47, SD =

10.490) and normal flow (M = 53.67, SD = 12.633) coronary arteries (t(110) = 2.86, p = 0.011). This finding suggests that patients with slow flow tend to be older compared to those with normal flow. Furthermore, the pre-QRSTA levels were significantly higher in patients with slow flow (M = 109.1408, SD = 23.10346) compared to those with normal flow (M = 60.9767, SD = 23.99379) coronary arteries (t(110) = 7.89, p < 0.001). This result indicates that patients with slow flow exhibit higher levels of pre-QRSTA, suggesting a potential association between slow flow phenomenon and myocardial ischemia. The Mann-Whitney test results demonstrated significant differences between the slow flow and normal flow groups in post-QRSTA levels (U = 3894.50, p < 0.001), change in QRS T angle (U = 1924.50, p < 0.001), TIMI flow (U = 2054.50, p < 0.001), and post TIMI values (U = 1081.00, p < 0.001). These findings suggest that patients with slow flow experience altered post-QRSTA levels, changes in QRS T angle, TIMI flow, and post TIMI values compared to patients with normal flow.

The present study provides valuable insights into the differences in age and pre-QRSTA levels between patients with slow flow and normal flow coronary arteries. The finding of older age in the slow flow group aligns with previous research suggesting that age is a risk factor for the development of slow flow phenomenon(Chalikias and Tziakas, 2021). Aging-related vascular changes, such as endothelial dysfunction and atherosclerosis, may contribute to the reduced coronary blood flow observed in slow flow patients(Wen et al., 2022). The age difference observed in this study highlights the importance of considering age as a potential confounding factor in future studies investigating slow flow phenomenon. The significantly higher pre- QRSTA levels in patients with slow flow indicate a potential association between slow flow and myocardial ischemia. QRSTA represents a measure of electrical instability, and elevated levels are indicative of myocardial damage or ischemia(Kahraman et al., 2019b). The findings suggest that patients with slow flow may be at a higher risk of myocardial ischemia, which could explain the adverse cardiac events associated with this condition. Further investigation is warranted to elucidate the underlying mechanisms linking slow flow and elevated pre-QRSTA levels. The Mann-Whitney test results revealed significant differences in post-QRSTA levels, change in QRS T angle, TIMI flow, and post TIMI values between the slow flow and normal flow groups. These findings indicate that patients with slow flow exhibit distinct electrocardiographic changes and altered cardiac parameters compared to patients with normal flow. The observed differences may contribute to the increased cardiovascular risk associated with slow flow phenomenon.

In terms of gender distribution, we observed that males constituted 33.9% of the slow flow group compared to 48.2% in the normal flow group (p = 0.263). Similarly, a comparison of MI types indicated that AWMI and IWMI were more prevalent among patients with normal flow (p = 0.204). Notably, the presence of SVCAD in CAD severity was significantly associated with flow patterns (p = 0.019). Furthermore, the occurrence of MACE was significantly higher in the slow flow group compared to the normal flow group (p < 0.001). The findings of this study provide insights into the relationships between flow patterns, cardiac conditions, and major adverse cardiac events. The lack of a significant association between gender and flow patterns suggests that slow flow may not be influenced by gender-related factors. The increased occurrence of MACE in the slow flow group highlights the clinical relevance of flow patterns in predicting adverse cardiac events. The observed frequencies for MACE (yes) are 10 (8.9%) in the slow flow group and 1 (0.9%) in the normal flow group. The p-value associated with the Chi-Square test for MACE is <0.001, indicating a significant association between MACE and TIMI flow.

The results of the Pearson correlation analysis between post QRSTA and post TIMI reveal a strong negative correlation (r = -0.740). Both variables show a statistically significant

association at the $p < 0.01$ level. These findings suggest that there is a significant relationship between the two variables. The negative correlation indicates an inverse relationship between post QRSTA and post TIMI. As the values of post QRSTA increase, the values of post TIMI tend to decrease, and vice versa. This strong negative correlation suggests that higher levels of post QRSTA are associated with lower levels of post TIMI. These results are consistent with previous research that has shown a negative correlation between these variables. Kahraman et al. conducted a similar study and found a significant negative correlation between post QRSTA and post TIMI in a sample of patients with cardiovascular disease(Kahraman et al., 2019b). Their findings support the idea that higher levels of post QRSTA are indicative of poorer TIMI flow outcomes. The negative correlation between post QRSTA and post TIMI could be explained by several factors. One possible explanation is that post QRSTA reflects the extent of myocardial damage or ischemia, which in turn affects the post-procedure TIMI flow(Güner et al., 2020). When there is more myocardial damage or ischemia, it may result in slower or impaired blood flow, leading to lower TIMI flow grades. These findings have important implications for clinical practice.

Monitoring post QRSTA levels in patients undergoing cardiovascular interventions can provide valuable information about the likelihood of achieving optimal TIMI flow. Identifying patients with higher post QRSTA levels can help healthcare professionals allocate appropriate resources and interventions to improve blood flow outcomes.

The results of the Pearson correlation analysis between post TIMI and Change in QRS T angle revealed a statistically significant positive correlation ($r = .388$, $p < .01$) between the two variables. This suggests that as post TIMI scores increase, there is a tendency for the Change in QRS T angle to increase as well. The findings of this study align with previous research that has also demonstrated a positive association between post TIMI and changes in QRS T angle. A study conducted in 2021 reported a significant correlation between post TIMI and changes in QRS T angle in a sample of cardiac patients(Işık et al., 2021b). This consistency in findings strengthens the validity and generalizability of our results. One possible explanation for the observed correlation is that post TIMI, which measures a patient's response to a cardiac intervention, may have a direct impact on the electrical activity of the heart, resulting in changes in the QRS T angle. The QRS T angle represents the electrical axis of ventricular depolarization and repolarization, and alterations in this angle can reflect abnormalities in cardiac electrical conduction. It is important to note that although the correlation between post TIMI and change in QRS T angle was statistically significant, the strength of the correlation ($r = .388$) suggests a moderate effect size. This indicates that while there is a relationship between the two variables, post TIMI alone may not fully explain the variance in the Change in QRS T angle. Other factors,

such as patient characteristics, comorbidities, or additional clinical variables, could contribute to the observed changes in QRS T angle.

The results of the Pearson correlation test between post TIMI and MACE indicate a significant negative correlation with a coefficient of -.410 ($p < 0.01$, two-tailed). This finding suggests that there is a relationship between the post TIMI score and the occurrence of MACE (Major Adverse Cardiac Events). The negative correlation suggests that as the post TIMI score increases, the likelihood of experiencing MACE decreases. This finding may have important clinical implications. The post TIMI score is a widely used tool for risk assessment in patients with cardiovascular disease, particularly those with acute coronary syndrome(Zhang et al., 2023). It incorporates various clinical parameters to estimate the likelihood of adverse cardiac events, including MACE. The negative correlation between post TIMI and MACE suggests that higher post TIMI scores are associated with better outcomes and a lower risk of MACE. These findings are

consistent with previous studies that have demonstrated the predictive value of the post TIMI score in assessing the risk of adverse cardiac events(Yang et al., 2021). This study found a similar negative correlation between the post TIMI score and MACE in a cohort of patients with acute myocardial infarction(Yang et al., 2021). Similarly, another study reported that higher post TIMI scores were associated with a decreased risk of MACE during long-term follow-up in patients with stable coronary artery disease(Grinberg et al., 2021).

The results of the Pearson correlation analysis between the secondary outcome variables, MACE and change in QRS T angle, reveal a statistically significant negative correlation. The correlation coefficient between MACE and change in QRS T angle is -.365, with a p-value of <0.001. The sample size for both variables is 112. This finding suggests that there is a significant association between MACE and change in QRS T angle. As the MACE increases, indicating a higher risk of major adverse cardiac events, the Change in QRS T angle tends to decrease. Conversely, a decrease in MACE corresponds to an increase in the change in QRS T angle. The correlation coefficient value of -.365 indicates a moderate negative correlation between the two variables. The negative correlation between MACE and change in QRS T angle may have important clinical implications. The QRS T angle is a measure of ventricular repolarization heterogeneity, and changes in this angle have been linked to an increased risk of adverse cardiac events(Dogan and Kahraman, 2020b). The significant negative correlation suggests that as the risk of major adverse cardiac events increases, there is a tendency for a decrease in ventricular repolarization heterogeneity (decreased Change in QRS T angle). These findings are consistent with previous research that has reported associations between markers of cardiac electrical abnormalities, such as the QRS T angle, and adverse cardiac outcomes(Subramanian et al., 2020). The negative correlation observed in this study reinforces the potential utility of the change in QRS T angle as a predictive marker for major adverse cardiac events.

Despite the valuable insights provided by this study, several limitations should be acknowledged. Firstly, the sample size of 112 participants may limit the generalizability of the findings to a larger population. A larger sample size would enhance the statistical power and improve the robustness of the results. Additionally, the study design is cross-sectional, which prevents the establishment of causal relationships between the variables. Longitudinal studies or randomized controlled trials would provide stronger evidence for causal associations. Moreover, the study focused on a specific population and setting, which may limit the generalizability of the findings to other patient populations or healthcare settings. The study's findings may not be applicable to individuals with different demographic characteristics or varying degrees of coronary artery disease severity. Despite these limitations, the present study contributes to the existing literature by providing valuable insights into the relationships between age, pre-QRSTA levels, flow patterns, cardiac parameters, and major adverse cardiac events in patients with slow flow and normal flow coronary arteries. Further research with larger sample sizes, longitudinal designs, and consideration of additional variables would help confirm and expand upon these findings, ultimately improving our understanding of slow flow phenomenon and its impact on patient outcomes.

CONCLUSION:

Patients with slow flow had a higher occurrence of MACE compared to those with normal flow, emphasizing the clinical relevance of flow patterns in predicting adverse cardiac events. There is a negative correlation between post QRSTA and post TIMI, a positive correlation between post TIMI and change in QRS T angle, and a negative correlation between MACE and both change in QRS T angle and post TIMI. These findings provide insights into the relationships between electrocardiographic parameters and cardiac outcomes, highlighting

the importance of age, pre- QRSTA levels, and electrocardiographic changes in patients with slow flow. Further research is needed to understand the underlying mechanisms and implications of these associations, potentially leading to improved risk assessment and management strategies for patients with slow flow phenomenon.

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