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Frontal QRS-T Angle as a Predictor of the Complexity of Coronary Artery Disease in Adults Presenting to a Tertiary Care Cardiac Hospital

Original Article

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Abstract

The study aimed to determine the association between the frontal QRS-T angle and the complexity of coronary artery disease, as defined by SYNTAX I score in patients presenting with chest pain to a tertiary cardiac care hospital, excluding those with acute coronary syndrome (ACS). The study employed has a descriptive cross-sectional design. The study was carried out at the Armed Forces Institute of Cardiology/National Institute of Heart Diseases (AFIC/NIHD), Rawalpindi, Pakistan, from October 2022 to August 2024. A total of 387 patients were included in the study in accordance with the inclusion and exclusion criteria. Non-probability consecutive sampling technique was used. Frontal QRS-T angle (fQRST) is automatically calculated by ECG machines based on a standard 12-lead Electrocardiogram (ECG). SYNTAX I score was calculated to assess the anatomic complexity of the coronary vasculature through angiography. According to results, out of 387 patients, 135 had coronary artery disease, and 45 with critical disease. fQRST ranged from 0-180° (median: 15°). SYNTAX-I score ranged from 0-33 (median: 0). Spearman's correlation analysis showed no statistically significant correlation between the fQRST, and SYNTAX-I score (rho = -0.011, p = 0.418). The study results conclude and suggest that fQRST may not be a good predictor of the complexity of coronary artery disease in our patients.

Keywords: Coronary Angiographies, Coronary Artery Disease, Electrocardiography, Vectorcardiography, Frontal QRS-T Angle.

Introduction

About 5% of the adults aged 20 and above have coronary artery disease (CAD), out of whom about 20% have silent heart attacks (Tsao *et al*., 2023). For stable CAD, the current prediction models only depend on conventional ECG findings (Q waves and ST-T changes) (He *et al*., 2017). Incorporating the innovative derived ECG parameter, fQRST, for predicting and stratifying CAD could enable early detection and better risk stratification without additional costs (DAAN *et al*., 2022). If the angle between the QRS complex vector and T wave vector is plotted in the frontal plain, it gives us fQRST, which represents the electrocardiographic ventricular gradient. It has recently gathered interest as a diagnostic and prognostic marker for various cardiac diseases (Oehler *et al*., 2014; Erdogan *et al*.,2020; Dogan *et al*., 2020; Aapo *et al*., 2012).

FQRST was found to be associated with SYNTAX-I score in stable CAD (Karadeniz *et al*., 2022), however, its usefulness as a predictor of stable CAD remains undefined. The complexity of coronary artery disease can be determined by the SYNTAX score (Sianos *et al*., 2005; Javed *et al*., 2019). In this score, the diseased areas in vessels of adequate size are individually scored based on their characteristics. These scores are then summed up to give a final score (Serruys *et al*., 2009; Farooq *et al*., 2013; Caixeta *et al*., 2012). It is one of the most used and validated tools for the assessment of the complexity of coronary artery disease (Hara *et al*., 2021). It helps in deciding CAD intervention by either coronary artery bypass graft (CABG) or percutaneous transluminal coronary intervention (PCI). This study aims to study the correlation between fQRST, and SYNTAX-I score in patients with stable CAD without prior ACS. This will contribute to understanding the role of a non-invasive and inexpensive marker in the diagnosis and stratification of CAD.

Methods and Materials

Study Design

This was a descriptive cross-sectional study performed at the Armed Forces Institute of Cardiology/National Institute of Heart Diseases (AFIC/NIHD), Rawalpindi, Pakistan, a teaching hospital, from October 2022 to August 2024.

Study Population

A total of 387 patients were included in the study in accordance with the inclusion and exclusion criteria. Non-probability consecutive sampling technique was used. The minimum sample size required, as calculated by putting 50% as for an unknown risk factor in the WHO calculator (WHO, 2020), was 384.

Inclusion Criteria

All patients more than 18 years of age presenting to AFIC with chest pain who underwent ECG and computed tomography coronary angiography (CTA) and/or invasive coronary angiography (ICA) were included in the study (Aryeh *et al*., 2016; Mo *et al*., 2021).

Exclusion Criteria

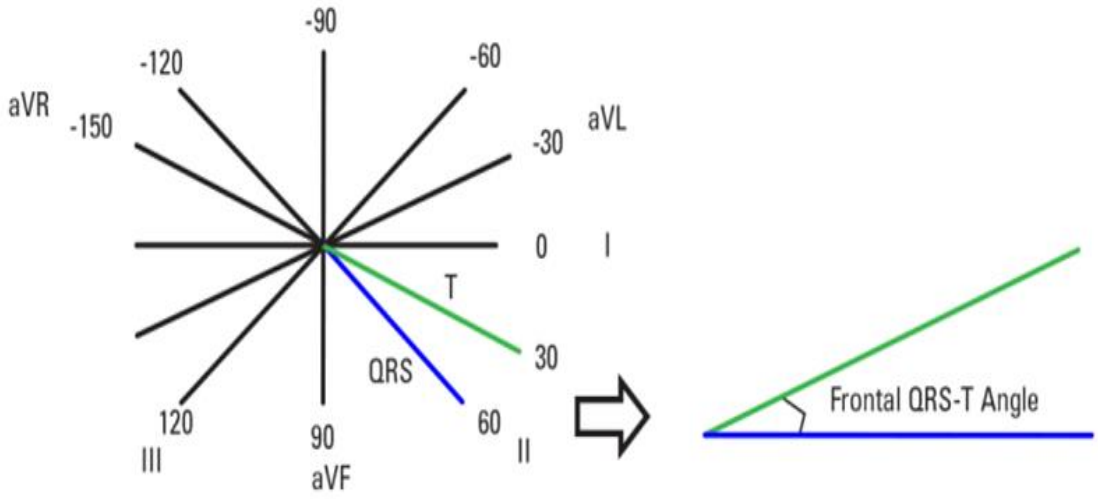
Patients presenting with previous history of ischemic heart disease (IHD), PCI or CABG, ECG changes showing ACS, (Thygesen *et al*., 2018; Sandoval *et al*., 2020) pathological Q waves, having long or short QT syndromes (Brugada syndrome), non-interpretable ECG, ECG changes associated with abnormal levels of potassium (RI 3.5-4.5 mg/dl) and calcium (RI 8.6-10.3 mg/dl), positive cardiac markers at the time of presentation, cardiomyopathies (dilated, restrictive and hypertrophic) and constrictive pericarditis, left ventricular hypertrophy (LVH), conduction abnormalities, chronic arrythmias, ventricular or atrial premature contractions of >1/minute (>60/hour), sinus node disease and atrioventricular nodal blocks, valvular heart diseases, congenital and other structural heart diseases, thyroid abnormalities, history of taking digoxin, antihistamines, antidepressants, QT prolonging antibiotics, were all excluded from this study.

Data Collection

Data was collected by a standardized questionnaire after taking informed consent, entered, and analyzed by SPSS version 22. The Frontal QRS and frontal T are frontal projections of three-dimensional QRS and T vectors. FQRST is defined as the absolute value of a 12-lead ECG's frontal QRS and T axis difference (Figure 1). If the difference exceeds 180°, then fQRST is calculated as 360° minus the absolute value. (Akin et al., 2021). Machine-generated values of the T wave and QRS axis were recorded. SYNTAX I score was calculated manually (Caixeta *et al*., 2012). Although lesions with less than 50% luminal occlusion are not graded by the SYNTAX score but for this study, such lesions were also graded to include non-obstructed CAD.

Figure 1

Measurement of planer frontal QRS-T angle



Source: (Oehler *et al*., 2014; Akin *et al*., 2021)

Data Analysis

Continuous data was tested for normal distribution by the Kolmogorov-Smirnov test. The data showed significant deviation from normality (p-value < 0.05); they were expressed as median(range). Categorical variables were recorded in frequency and percentages. Spearman's correlation coefficient (rho) and linear regression were used to determine the association between fQRST angle and SYNTAX I score. Two groups based on the presence or absence of CAD (SYNTAX-I 0 or >0) were made. The Mann-Whitney U Test and Spearman's correlation were used to determine the difference in fQRST in both groups, and the correlation of fQRST and SYNTAX-I in the diseased group. Logistic Regression was used to determine the predictive ability of fQRST for the SYNTAX-I score.

Ethical Considerations

The present study was carried out in conformity with the ethical norms of the Institutional Review Board (IRB) of the Armed Forces Institute of Cardiology. All the participants signed a consent form to participate in the study before they were included in the study. To ensure patients' identities were not revealed, the identity of all the patients' information was concealed to ensure patient confidentiality. Further, participants were made aware of their rights, where they could withdraw from the study at any time without compromising their treatment.

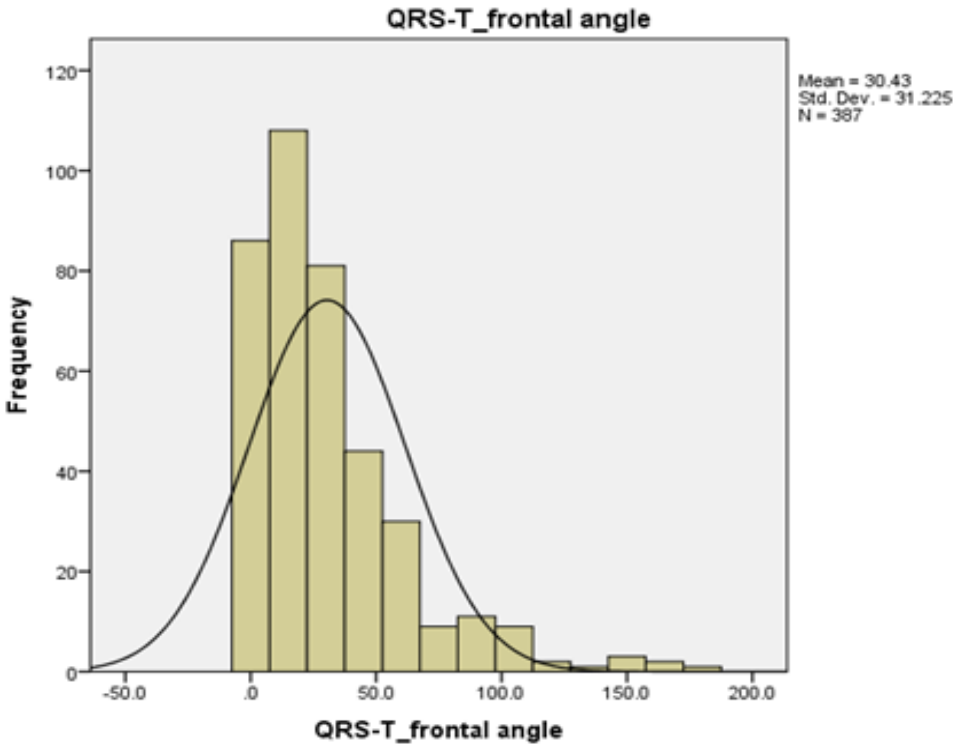
Results and Findings

Descriptive Statistics of Test Parameters

Out of a total of 387 patients, only 8 (2.1%) were females, ranging from 28-68 years of age (mean 52.5±12.4). The age range of 379 (97.9%) male patients was 20-73 (mean ± SD: 38.5 ±7.9) years. The prevalence of coronary artery disease in our study population was 135/387(35%). There were 45/387 (11.6%) diabetic patients, out of which 32/45 (71.1%) had CAD. There were 91/387(23.5%) hypertensive patients out of which 45/91(49.5%) had IHD.

Figure 2

The Frequency Distribution of fQRST Angle.



The results are portrayed in Figure 2 regarding the frequency histogram of the fQRST angle (n = 387, mean = 30.43, SD = 31.43). Syntax I score was 0(0-33) median(range). Based on fQRST, the categorization of patients to normal (<30°), borderline (30-89°), and abnormal (>90°) was done (Walsh *et al*., 2013). There were 275/387 (70.1%) cases in the normal group, 94/387 (24.3%) in the borderline group, and 18/387 (4.7%) in the abnormal/wide fQRST. Only 135/387(35%) had CAD, out of whom a mere 45/387(12%) had critical disease (>70% luminal narrowing).

Correlation Studies

Spearman's correlation showed no significant relationship between fQRST, and SYNTAX-I score (rho=-0.011 and p=0.418). Linear regression analysis of fQRST and SYNTAX-I score did not show any relationship between these parameters (F=0.324, p=0.570, β=0.029). The median(range) for fQRST was 15° (0-165°), whereas for SYNTAX I score it was 1(0-33) in disease group. Spearman's correlation between fQRST and syntax I score for the disease group was statistically not significant (n=130, rho=0.48, p=0.293).

The Mann-Whitney U test and Regression Analysis

There was no statistically significant difference for fQRST values between both groups as determined by Mann Mann-Whitney U test (z=-0.422, p= 0.673). Logistic regression failed to show that fQRST had significant power to predict SYNTAX-I score (p=0.946, Odds ratio 1.0).

Discussion and Conclusion

The male-dominant cohort (97.9%) contrasts with the 3:1 male-to-female ratio reported by Tariq *et al*. (2020) from Lahore. Gender difference may be due to strict inclusion and exclusion criteria or because of predominant male presentation for investigations or treatment at a tertiary cardiac hospital. Another reason could be due to the contraindication of pregnancy for radiological investigations, thus under-representation in the current study. This could also be due to female hormones having a protective effect during the reproductive years of women (Skafar *et al*., 1997; Xiang *et al*., 2021). Our results are like two other studies from Pakistan (Durrani *et al*., 2022; Farooq *et al*., 2023), both of which failed to show any significant relationship between the two parameters. On the other hand, our findings contradict those of some previous studies that suggested a potential correlation (Iqbal *et al*., 2021; Khan *et al*., 2018). Several factors may explain this discrepancy, including differences in patient demographics, sample sizes, and methodologies used to calculate fQRST and SYNTAX scores.

One study done by Akin *et al*. used the Gensini score, which scores each coronary artery stenosis and applies a multiplier based on functional importance. The score of individual stenosis is then added together to form a final score. When comparing it with SYNTAX score, later is a better indicator of the complexity of CAD as it includes calcifications and bifurcations in its calculations. The SYNTAX score was found to be more closely associated with atherosclerotic markers such as carotid intimal thickness and epicardial fat (Kalkan *et al*., 2018) as compared to the Gensini score. They studied 202 patients with stable coronary artery disease without any previous history of coronary artery disease and grouped the patients into mild CAD and severe CAD based on the Gensini score > 25. They found a significant difference in fQRST between both groups, with the severe group having higher average fQRST values (53° vs 93°). Another study in patients with stable CAD showed a significant association between fQRST and SYNTAX-I score (Karadeniz *et al*., 2022). They included 403 subjects with stable angina and divided them into two groups based on the SYNTAX-I score of 0 and >0. They found a significant difference in fQRST between these groups.

When we compared our patients with SYNTAX-I scores of 0 and >0, we did not find any significant difference between the two groups. Comparing our study population with Akin *et al*. (2021) and Karadeniz *et al*. (2022), several important differences were found. Notably, our cohort was younger (38.7±8.2) as compared to Akin *et al*. (60.16±11.27) and Karadenz *et al*. (66.60±12.36). Additionally, our patients had simpler CAD as indicated by lower syntax score (2.1±4.3) as compared to their patients. Only 12% of our patients had severe CAD as compared to 52% in Akin *et al*. Interestingly, both studies were conducted in Turkey, which may point to cultural, social, and/or genetic factors that could also contribute to observed differences in our and their findings. It is widely known that age is a non-modifiable risk factor for CAD; therefore, in the younger population, fQRST may not be as reliable a maker of CAD as in the older population.

Few studies (Aswar *et al*., 2022; Kaya, 2020) have shown a significant association of SYNTAX score with fQRST in patients with ACS. This shows that fQRST has a role in the diagnosis and management of CAD patients, especially with more complex and functionally important CAD. This can be explained by the fact that minor lesions do not cause a significant reduction in blood flow, especially at rest, and do not produce any significant effect upon the depolarization and repolarization processes of the heart. Wide fQRST in these patients may represent other pathologies besides CAD. This shows that fQRST's role in the diagnosis and management of CAD is more beneficial in patients with more complex and critical CAD. Our study concludes that no statistically significant correlation existed between fQRST, and SYNTAX-I score. Therefore, it cannot be used as a predictor of the complexity of CAD in our patient population.

Limitations

This was a single-center cross-sectional analysis; therefore, the results may not apply to the general population. This study also did not include enough patients of female patients and patients of older age groups with higher SYNTAX-I scores to form a reliable conclusion in this subset of the population. Larger, multi-centered studies with balanced gender representation are recommended to further elucidate the utility of fQRST in CAD risk stratification. The score used in this study has a limited role than SYNTAX-II in predicting cardiac outcomes.

Future Research Directions

It is suggested that further studies with a larger sample size of patients with more complex CAD might help establish a relationship between fQRST and SYNTAX-score. Other avenues of future studies can include machine learning models incorporating 3D anatomical information from CTA and ECG parameters (spatial and frontal QRST angles) to establish their role in CAD management. Longitudinal studies examining the role of change in fQRST and SYNTAX score after intervention (risk factor modification, PCI, and CABG) can also reveal meaningful information. The SYNTAX-II score was introduced to include clinical information into the calculations and has shown better results than the SYNTAX-I score (Farooq *et al*., 2013). The use of SYNTAX-II in future studies can also potentially lead to better correlation with fQRST.

Declarations

Ethical Approval and Consent to Participate: This study strictly adhered to the Declaration of Helsinki and relevant national and institutional ethical guidelines. Informed consent was not required, as secondary data available on websites was obtained for analysis. All procedures performed in this study were by the ethical standards of the Helsinki Declaration.

Consent for Publication: Not Applicable.

Availability of Data and Materials: The data set of this study could be provided subject to a formal request addressed to the corresponding author.

Competing Interest: The authors declare that they have no competing interests.

Funding: Not Applicable.

Authors' Contribution: Both authors, Dr. Asif Dawood and Professor Muhammad Shabbir, worked together in conducting the study, writing, and submission to the journal.

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