Cross-Sectional Study

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Usefulness of electrocardiography QT interval for prediction of left ventricular diastolic dysfunction: a cross-sectional study

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Introduction: Heart failure (HF) is a leading cause of morbidity and mortality worldwide, with projections showing a further rise in incidence, impacting a decline in quality of life and the costs incurred in its diagnosis and treatment. The authors aim to establish the correlation between the prediction of left ventricular diastolic dysfunction based on a change in QT wave intervals.

Methods: A cross-sectional at Holy-family Hospital, Rawalpindi Medical University, Pakistan. One thousand five hundred patients were referred for electrocardiography (ECG) for clinical suspicion of HF between May and July 2022. Ejection fraction (EF), lateral mitral annulus velocity (e'), mitral inflow early (E) and late (A) velocities, left ventricular filling pressure (E/e' ratio), and QT interval (QTc) was calculated. Odds ratios with a 95% CI (odds) were obtained by comparing QTc with all variables.

Results: The patients were mostly middle-aged adults with a mean age of 30.27 (±7.64). Male to female ratio was nearly balanced, with 771 (51.4%) males included in the clinical survey. The ECG parameters were; QT interval—494.07 (±63.61), EF—57.11 (±11.96), early to atrial filling velocity ratio—0.71 (±0.20), and lateral mitral annulus velocity—8.29 (±1.64).

Conclusion: The promising results for correlation between QT interval and ECG parameters, particularly EF and lateral mitral annulus velocity, should not be considered as the alternative in diagnosing left ventricular diastolic dysfunction thus far. Prolonged electrocardiographic QTc interval in patients with HF is useful in predicting diastolic dysfunction.

Keywords: Diastole, electrocardiography, ventricular dysfunction, QT interval

Introduction

Heart Failure (HF) is a leading cause of morbidity and mortality worldwide, with projections showing a further rise in incidence[1]. HF impacts a huge world population with an associated decline in quality of life and the costs incurred in its diagnosis and treatment. Left ventricular diastolic dysfunction (LVDD) is widely considered an early manifestation of an impending HF and, therefore, a major contributor to mortality in patients with HF[2]. LVDD can arise from impairments in four ventricular diastolic phases, i.e., the Isovolumic relaxation period, rapid filling period, diastasis, and atrial systole[3]. All of these phases rely on left ventricular elasticity, relaxation, and lengthening in one way or another. Hence, mechanical abnormalities in these phases, including rigid ventricular walls and reduced relaxation, can increase left ventricular filling pressure, leading to LVDD[4].

Diagnosing diastolic dysfunction typically involves echocardiography. Diagnosing and classifying the extent of diastolic dysfunction is aided by a number of echocardiographic measures. According to one study, the specificity and sensitivity of several echocardiographic measures in determining diastolic dysfunction were 95% and 100%, respectively. Although echocardiography is the traditional method of diagnosing HF, studies have found a correlation between these mechanical abnormalities with a prolonged QT interval on electrocardiography in patients with long QT syndrome[5]. Moreover, as echocardiography is not offered in primary care

HIGHLIGHTS

- Heart failure impacts a huge population of the world with an associated decline in quality of life and the costs incurred in its diagnosis and treatment.
- This study employs the QT interval in predicting left ventricular diastolic dysfunction.
- It has in-depth study analysis of all the patients to ensure authenticity.

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settings and requires an expert to investigate and analyze the findings, we need to establish guidelines for electrocardiography as a preliminary investigation for the prediction and diagnosis of LVDD in primary care before echocardiographic studies.

Previously, studies have been conducted to determine if electrocardiographic findings can accurately predict LVDD[6], concluding that QTc, P wave inversion, and a hump in ST-segment on exercise may be associated with a higher incidence of diastolic dysfunction. However, there's still a need for a deeper understanding of electrocardiography (ECG) findings, especially for establishing a diagnosis and prediction of LVDD. In our study, we aim to establish the correlation between the prediction of LVDD based on the change in QT intervals.

Methods

We conducted a prospective, single-centred cross-sectional study at Holy-family Hospital, Rawalpindi Medical University, Pakistan. The Rao-soft calculator was used to calculate the estimated study size of 1500 patients keeping the 5% error margin and 95% CI. The data were collected between May and July 2022.

Our study is fully compliant with the STROCSS 2010 guidelines[7]. A complete STROCSS 2021 checklist has been provided as a supplementary file. UIN researchregistry8289[8] identifies our study in Research Registry. Our research adheres to the principles outlined in the Helsinki Declaration.

Before the data collection process was completed, the ethical permission was approved by the Institutional Review Board (IRB) of the Holy Family Hospital, Rawalpindi Medical University, Pakistan.

Data of only those patients who were referred to ECG for clinical suspicion of HF were studied. Before including in the study, every patient had explained the aims and objectives of the research in detail; after that, the consent form was filled out by either the patient himself or the attendee of the patient.

Data collection was divided into two parts. In the first part, brief demographic detail was obtained, including the age and gender of the patients. Common comorbidities such as hypertension, diabetes, and coronary heart diseases were also obtained if present. The second part was related to the numerical values of the heart functioning of the patients. It included ejection fraction (EF), lateral mitral annulus velocity (e'), mitral inflow early (E) and late (A) velocities, left ventricular filling pressure (E/e' ratio)[9], and QT interval (QTc). Each variable was divided into two categories (dichotomous), normal and abnormal. Normal values considered in this study for E/A ratio, e', E/e ratio, QT interval, and EF were considered greater than 0.8, greater than 8 cm/s, less than15, 430–500 ms, and 61–80%.

IBM SPSS statistics 24[10] was used to analyze the extensive data. Sex and comorbidities were analyzed as frequencies. Mean, and SD was calculated for continuous variables like age, EF, E/A ratio, and e', e/e' ratio. The 5 clinical variables were then expressed as dichotomous variables in two categories, as explained above. QTc was considered an independent variable. Odds ratios with a 95% CI were obtained by comparing QTc with all four variables. After the decimal in the lower and upper CI values, the same first digit was considered significant. A χ^2 test was also conducted between the dichotomous QTc and comorbidities variables. *P* values less than 0.05 was considered significant.

Results

Baseline characteristics

The patients enroled in the study were mostly middle-aged adults with a mean age of 30.27 (±7.64). The ratio of the males and females was kept nearly balanced with the 771 (51.4%) included in the clinical survey. The few most common comorbidities reported were coronary heart disease, diabetes, and hypertension [732 (48.8%) and 338 (22.5%)]. The mean (SD) of the included ECG parameters were; QT interval—494.07 (±63.61), EF—57.11 (±11.96), E/A ratio—0.71 (±0.20), E/e ratio—15.64 (±1.82), and lateral mitral annulus velocity—8.29 (±1.64).

Clinical suspicion of HF is defined as patients with the symptoms of orthopnea, dyspnoea, and low-extremity oedema who were referred to the ECG by the attending doctor. An extensive range of cardiac conditions, systemic diseases, and hereditary defects can result in HF. More than two-thirds of all cases of HF can be recognized as four fundamental conditions: chronic obstructive pulmonary disease, hypertensive heart disease, ischaemic heart disease, and rheumatic heart disease.

Chi-square association

QT interval was observed to be significantly lower in coronary heart disease patients 732 (100%); on the other hand, it was found to be increased in hypertensive patients 338 (100%), while the minority of the diabetic patients had it increased 91 (26.84%). The *P* values were calculated to be highly significant (Table 1).

Associations between ECG parameters

QT interval, considered the independent variable, was analyzed with the other ECG parameters to examine whether a change in the QT interval is associated with the change in other ECG variables.

Upon comparison of EF at normal and abnormal QT intervals, it was observed that EF significantly decreased 429 (100%) in patients with an abnormal QT interval. Although there were patients with decreased EF at normal QT intervals as well, a huge number of patients with normal EF at normal QT intervals, 573 (53.5%), were also present. This showed the linear relation of the two variables, hence, the significant odds ratio (CI) value (Table 2).

At normal QT intervals, the E/A ratio was observed to be abnormal in the majority of patients 841 (77.9%). At abnormal QT intervals, the E/A ratio was abnormal in all patients, 429 (100%). Hence, the odds ratio and CI were calculated as non-significant or nonlinear (Table 3).

Lateral mitral annulus velocity was found to be normal at normal QT intervals in most patients 429 (84.1%) when

Table 1

Association between comorbidities and QT interval

QT interval	Hypertension	Coronary heart disease	Diabetes	*P*
430–500	0	732	339	0.000
502–785	338	0	91	

Table 2
Association between QT interval and ejection

	Ejection fraction			
QT interval	38–60	61–80	Odds ratio	95% confidence interval
430–500	498	573		
501–785	429	0	0.465	0.436–0.496

observed with the independent variable. We were noticed to be abnormal/slow with prolonged/abnormal QT intervals in all the patients 901 (100%). This explains the linear relation between the two variables [significant odds ratio (CI)] (Table 4).

The early mitral inflow velocity to early diastolic mitral annulus velocity ratio E/e' ratio had a nonlinear relationship with the QT interval according to the analysis of this study. At normal QT intervals, patients in bulk had an abnormal E/e' ratio of 429 (72.8%). Therefore, the odds ratio of (77995%) CI was non-significant (Table 5).

Discussion

LVDD is defined as the decelerated or incomplete left ventricular filling due to the failure of the cardiac sarcomeres to return to their resisting length; as a result, the left ventricle cannot accept blood at low pressure unless atrial pressure increases[11]. In this study, we investigated the effectiveness of Electrocardiographic QT intervals in assessing LVDD by investigating the correlations between QT intervals with multiple ECG parameters.

The statistical analysis demonstrated a significantly lower QT interval in coronary artery disease patients. This finding was corroborated by an earlier comparative study[12] and contradicted a study conducted on patients with stable angina[13]. According to the results of this study, corrected QT interval prolongation (odds ratio, 2.27; 95% CI, 1.81–2.85) was linked with obstructive coronary artery disease. Even though the results were proven statistically significant ($P < 0.001$), the large disparity between the number of males and females included limits the credibility of the results[14].

The underlying mechanism of prolongation of QT interval in hypertensive patients is still unclear. However, it has been postulated that Left ventricular hypertrophy, caused by hypertension as well as antihypertensive drugs could lead to changes in cardiac repolarization[15].

It has been seen that prolonged QT interval is associated with an increased sympathetic tone, which may lead to hypertension, atherosclerosis, and other cardiovascular events[16]. It was also found that most diabetics had a low QT interval. This finding was contraindicated by an earlier study that associated prolonged QT intervals with autonomic neuropathy in diabetes[17]. However, the authenticity of this finding could have been improved by the opinionated design of the study, which could be biased.

A significant correlation between abnormal QT intervals and decreased EF was drawn in this study. This was consistent with the findings of an earlier study[18] which also assessed the correlation between EF and QT intervals. Moreover, a large-scale multi-ethnic study established that abnormalities in ventricular repolarization that lead to prolonged QT interval and reduced EF depict anatomical defects instead of diastolic dysfunction[19]. Furthermore, an earlier observational study established a strong association between drug-induced QT prolongation and preserved EF[20].

Our study showed that QT interval was nonlinearly/non-significantly associated with the E/A ratio (ratio of the peak velocity blood flow from LV relaxation in early diastole to peak velocity flow in late diastole caused by atrial contraction). An interesting finding was reported in a recent study which showed an increase in the E/A ratio from less than 1 (in early stage LVDD) to more than 1 in the pseudo normal stage and finally, the highest value of E/A ratio in the restrictive stage[21]. Another observational study that assessed LVDD based on electrocardiographic parameters demonstrated significantly lower E/A ratios in the LVDD group compared with the non-LVDD group[22].

In-study analysis showed a linear/significant association between QT interval and lateral mitral annulus velocity. It is an important factor in assessing LVDD because, under normal physiological conditions, a significant proportion of LV ejection results from apical descent of the mitral annulus, which could decrease in the setting of dysfunction. An earlier observational study investigating lateral and septal mitral annulus velocity in assessing LVDD concluded that lateral mitral annulus velocity is an accurate and precise measure of LVDD[23]. This finding was corroborated by the results of another similar study, which added that lateral mitral annulus velocity is particularly useful in detecting pseudo-normalization patterns of mitral inflow[24].

Table 3
Association between QT interval and E/A ratio

	E/A ratio			
QT interval	0.3–0.7	0.8–1.3	Odds ratio	95% confidence interval
430–500	841	239	0.215	0.192–0.241
501–785	0	429		

E/A, early to atrial filling velocity ratio;

Table 4
Association between QT interval and lateral mitral annulus velocity

	Lateral mitral Annulus velocity			
QT interval	5–7.5	8–12.5	Odds ratio	95% confidence interval
430–500	170	901	0.159	0.138–0.182
501–785	429	0		

Table 5
Association between QT interval and E/e ratio

	E/e ratio			
QT interval	12–15	15.5–19.5	Odds ratio	95% confidence interval
430–500	291	779	0.272	0.247–0.300
501–785	429	0		

E/e', early mitral inflow velocity to early diastolic mitral annulus velocity ratio

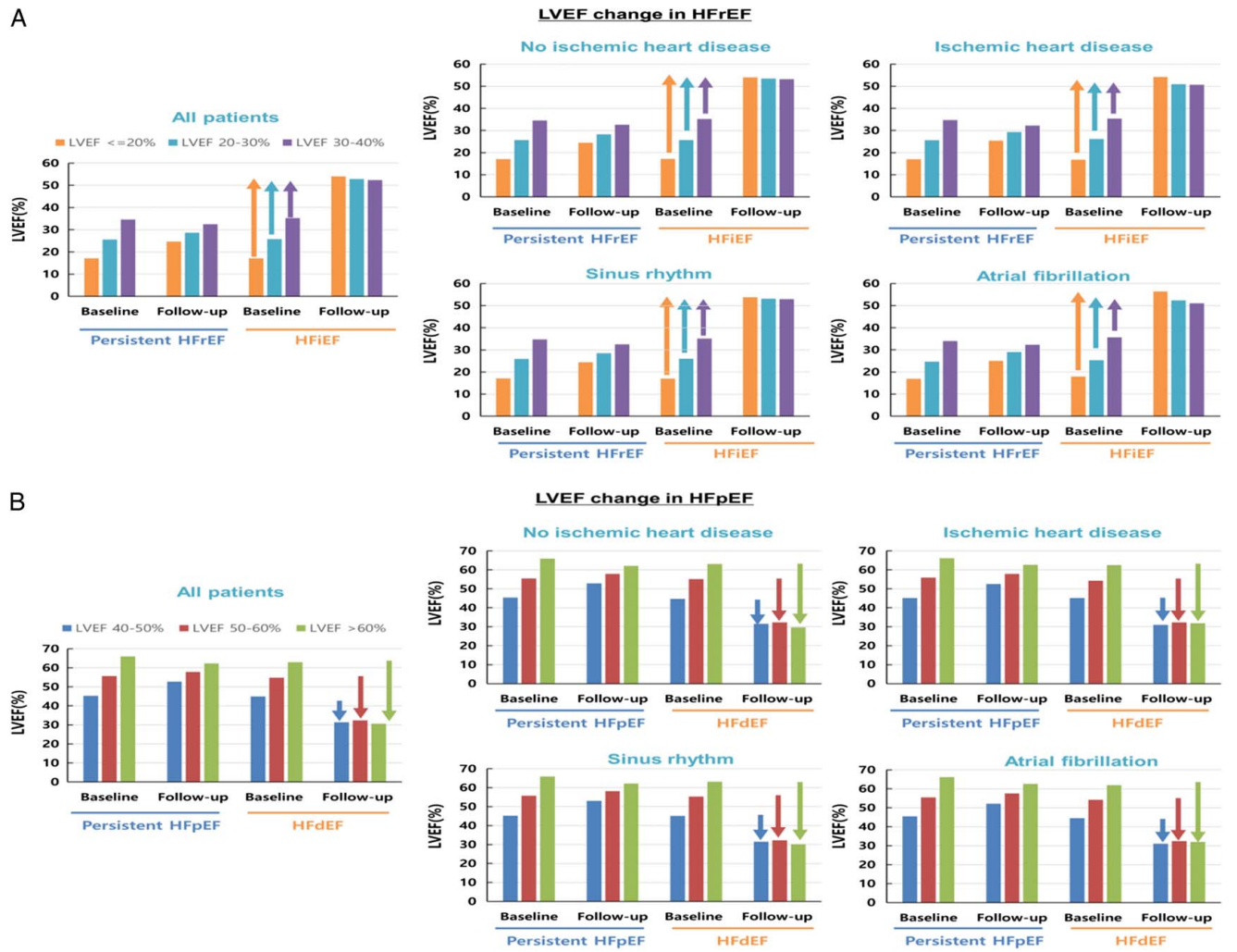

Figure 1. Longitudinal changes in ejection fraction according to heart failure (HF) phenotypes and baseline ejection fraction. HFDeF, heart failure with depressed ejection fraction; HFrEF, Heart failure with reduced ejection fraction; HFpEF, Preserved ejection fraction; LVEF, Left ventricular ejection fraction.

This study established a nonlinear/nonsignificant correlation between the QT interval and E/e ratio. However, an earlier observational study demonstrated the usefulness of the E/e ratio in predicting LVDD and mortality in patients with chronic kidney disease[25]. Furthermore, Korean research comparing the effectiveness of the E/e ratio versus E/A ratio in assessing LVDD in patients with systemic sclerosis established that the E/e ratio is more sensitive than the E/A ratio[26]. Another observational study of 1168 healthy Caucasian adults established the E/e ratio to accurately measure LVDD[27].

Limitations/strengths

This is one of the first few cross-sectional studies to employ the QT interval in predicting LVDD. Another similar study investigated the efficacy of electrocardiographic parameters in speculating LVDD.[28] The limitations of our study are that it lacks specific parameters evaluated in the initial study, for example, hyperlipidemia, medications, LV mass index, and LA volume index, and it also did not evaluate the grades of LVDD. Another area for improvement is that it is a single-centred approach that lacks scientific rigour and is devoid of external validity achieved by multicentered studies. However, this single-centred approach allowed us to perform an in-depth study and analysis of all the patients to ensure the authenticity of our results. The large patient population size is another strength of this study which enhances the reliability of the findings and enables us to apply the results to the general population.

Conclusion

The promising results for the correlation between QT interval and ECG parameters, particularly EF and lateral mitral annulus velocity, should not be considered as the alternative in diagnosing LVDD thus far. However, further large-scale multicentred studies assessing additional variables are needed to validate our findings thoroughly.

With high specificity and sensitivity values, persistent electrocardiographic QTc interval is a convenient diagnostic test for predicting diastolic dysfunction in patients with suspected heart failure (Fig. 1).

Ethical approval

Ethical approval was obtained by Holy family Hospital, Rawalpindi Medical University, Pakistan, Dated 17 Aug 2022.

Consent

Obtained from all the authors for final submission.

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Conflicts of interest disclosure

No conflict of interests declared by the authors.

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