ORIGINAL RESEARCH PAPER

Cardiology

DIAGNOSIS OF LEFT VENTRICULAR DIASTOLIC DYSFUNCTION ON RESTING ECG – A PROSPECTIVE STUDY

KEY WORDS: Diastolic Dysfunction, Resting ECG, Morris Index, corrected QT Interval

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ABSTRACT

Background: Heart failure due to preserved as well as reduced ejection fraction is a major healthcare challenge; echocardiography, including tissue Doppler Imaging (TDI) serves as the cornerstone of its diagnosis. ECG is a widely available, relatively inexpensive tool for predicting left ventricular diastolic dysfunction (LVDD).

Objectives: We aimed to study different parameters in resting 12-lead ECG to evaluate whether they can predict LVDD diagnosed on detailed echocardiography including TDI.

Methods: This was a cross-sectional study of 39 patients undergoing echocardiographic study in cardiology department of our institute. They were classified into two groups based on LVDD (Group 1 Normal, Group 2 LVDD) and their resting 12-lead ECG was analyzed for following parameters: QT interval, corrected QT interval, P wave duration (PW-D) and height (PW-H) in Lead 2, P terminal wave duration (P term-D) and height (P term-H) in lead V1, P wave terminal force in lead V1. Correlation of these parameters with LVDD was investigated.

Results: Study included 39 patients, females 16, males 23, with age range 20-87 (mean 48) years. Group 1 comprised of 14 normal echo patients and 25 patients with LVDD were in Group 2. The Mean QTc was 419ms (SD 21) and 440ms (SD 30) in Group 1 and Group 2 respectively, which was statistically significant ($p = 0.03$). The P terminal wave duration V1 difference was statistically significant ($p = 0.03$) with a mean of 39 ± 17 ms vs 52 ± 19 ms in Grp 1 and Grp 2 respectively. P terminal wave height V1 was 0.79 ± 0.26 mm in Grp 1 and 1.1 ± 0.41 mm in Grp 2, which was statistically significant ($p = 0.01$). Morris Index was statistically highly significant between the two groups (0.03 ± 0.02 mm.s Grp1 and 0.07 ± 0.04 mm.s in Grp2, $p = 0.009$). P wave height lead 2 was 1.1 ± 0.4 mm and 1.7 ± 0.6 mm in Grp 1 and Grp 2 respectively ($p = 0.002$). P wave duration in Lead 2 did not find significance statistically ($p = 0.08$) with mean 90 ± 19 ms versus 103 ± 26 ms in Group 1 and 2 respectively.

Conclusion: QTc, P terminal wave duration and amplitude in V1, Morris Index, and P wave amplitude in lead 2 are significantly higher in patients with echocardiographic diagnosis of LVDD.

INTRODUCTION

Left ventricular diastolic dysfunction (LVDD) is defined as “inability of the LV to fill during rest or exercise, to a normal end-diastolic volume without an abnormal increase in LV end diastolic pressure”¹. Prevalence of asymptomatic diastolic dysfunction in the general community is ~25–30% in individuals ≥ 45 years², while diastolic function is frequently abnormal in patients with systolic dysfunction.

Diagnostic evidence of LVDD can be obtained invasively (as elevated LV end-diastolic pressure) or non-invasively by TDI, coupled with plasma levels of natriuretic peptide³. Several echocardiographic parameters, such as, blood flow Doppler of mitral valve or pulmonary veins, echo measures of LV mass index or left atrial volume index have been validated to diagnose LVDD³.

ECG is a widely available, even in primary care, unlike echocardiography. Hence, there has been interest in investigating ECG features to predict LVDD^{4,5}. QTc interval prolongation has shown to be predictive and correlate with LVDD in previous studies^{4,5}. ECG features of left atrial dilatation, such as prolonged P wave duration, increased P wave dispersion, have specifically been focus of interest and have shown to correlate well with LVDD.

AIM OF THE STUDY

In this study, we aimed to study different parameters in resting 12-lead ECG and evaluate whether they can predict left ventricular diastolic dysfunction (LVDD) diagnosed by detailed echocardiography including Tissue Doppler Imaging (TDI).

SUBJECTS AND METHODS

This cross-sectional study was carried out in the outpatient department (OPD) of cardiology, at our institute. Consecutive patients who attended cardiology OPD and underwent ECG and detailed echo including TDI were included in the study.

Inclusion Criteria:

- A) age above 18 years
- B) clinically stable

Exclusion Criteria:

- A) active ischemia
- B) dyselektrolytemia
- C) Were on QT prolonging drugs/ anti-arrhythmic (class 1 and class 3) drugs.
- D) Presence of atrial flutter/ fibrillation, bundle branch block or Wolff-Parkinson-White syndrome on baseline ECG.

ECG Measurements:

These were performed with digital calipers on desktop screen image of the 12-lead ECG.

1. QT interval and corrected QT interval (QTc) ms: This was measured from the beginning of longest QRS complex to the end of T wave. QTc was obtained by dividing the actual QT by the square root of RR interval.
2. P wave duration in lead 2 (PWD-L2) ms: In L2, P wave duration was measured beginning to end as it crosses isoelectric line in 3 beats and average of the 3 beats was taken.
3. P wave height amplitude in lead 2 (PWH-L2) mm: TP segment was considered isoelectric and in lead 2, P wave height was measured from its peak to isoelectric line.
4. P terminal wave duration in lead V1 (P TermD-V1) ms: Measured as duration of downward deflection of terminal part of P wave in lead V1
5. P terminal wave height in lead V1 (P TermH-V1) mm: Measured as amplitude of downward deflection of terminal part of P wave in lead V1.
6. Morris Index: P wave terminal force in lead V1 (PTFV1), referred to as the Morris index, is a product of the amplitude (mm) and time (s) of a terminal negative P wave. Normal value is < 0.04 mm.s.

Echocardiographic measurements

Trans-thoracic imaging was performed in the left lateral decubitus position using a GE Vivid T9 machine (GE Medical Systems, WI), equipped with 2.5 MHz phase array transducer and TDI software. A detailed echocardiographic study using conventional and TDI techniques was done on all patients to estimate diastolic LV function⁵. The ratio of trans-mitral early LV filling velocity (E) to early diastolic Doppler tissue imaging velocity of the mitral annulus (transmitral E/E') was computed and if ≥ 15 was considered abnormal and a reliable indicator of LVDD (ESC). Patients were classified into 2 groups based on this ratio- those with normal E/E' in Group 1 and those with abnormal value into Group 2.

Statistical Analysis:

Statistical analysis was performed using IBM SPSS statistical software, version 21.0 (SPSS, Chicago, IL). Values for continuous variables are expressed as mean $\pm$ SD, whereas, for categorical variables, as observed number and percentage. Independent t test was used for comparisons between the 2 patient groups, for continuous variables. Significance level was set at $p \leq .05$.

RESULTS

Study included 39 patients, males 23 and females 16, with age range 20-87 (mean 48) years. Group 1 comprised of 14 patients with no LVDD on echo and Group 2 consisted of 25 patients with LVDD. In 5 patients of Grp 2, there was additional significant LV systolic dysfunction.

The Mean QTc was 419ms (SD 21) and 440ms (SD 30) in Group 1 and Group 2 respectively, which was statistically significant ($p = 0.03$). The P terminal wave duration V1 difference was statistically significant ($p = 0.03$) with a mean of 39 ± 17 ms vs 52 ± 19 ms in Grp 1 and Grp 2 respectively. P terminal wave height V1 was 31 ± 10 ms in Grp 1 and 44 ± 16 ms in Grp 2, which was statistically significant ($p = 0.01$). P wave height lead 2 was 44 ± 16 ms in Grp 1 and 69 ± 25 ms in Grp 2 respectively ($p = 0.002$). P wave duration in Lead 2 did not find significance statistically ($p = 0.08$) with mean 90 ± 19 ms versus 103 ± 26 ms in Group 1 and 2 respectively. (Table 1).

Table – 1 Comparison Of Ecg Parameters In Patients With Nrmal (group 1) And Impaired Lv Diastolic Function (group 2).

ECG Variable	Group 1 (n 14)	Group 2 (n 25)	p value (Sig ≤ 0.05)
QTc ms	419 $\pm$ 21	440 $\pm$ 30	0.028
P Term D-V1 ms	39 $\pm$ 18	53 $\pm$ 19	0.032
P Term H-V1 mm	0.79 $\pm$ 0.26	1.1 $\pm$ 0.41	0.010
Pterm F-V1	0.03 $\pm$ 0.02	0.07 $\pm$ 0.04	0.009
PW H-L2 mm	1.1 $\pm$ 0.4	1.7 $\pm$ 0.6	0.002
PW D-L2 ms	90 $\pm$ 19	103 $\pm$ 26	0.08

QTc: corrected QT interval, PTermD-V1: P terminal wave duration V1. PTerm H-V1: P terminal wave height V1, PTerm FV1: P terminal Force V1, PW H-L2: P wave height lead2, PW D-L2: P wave duration L2.

DISCUSSION

In this prospective study of 39 consecutive patients, we found several ECG parameters to be of significantly higher occurrence in patients with LVDD. These included corrected QT interval, P terminal wave duration and height in lead V1, Morris Index, P wave height in lead 2. However, the P wave duration in lead 2 did not attain but showed trend towards statistical significance, probably due to small sample size.

Qtc And Qt Interval^{4,5,7}:

We found mean QTc was significantly more prolonged in LVDD than in normal subjects, similar to other studies. In studies of individuals without CAD (based on stress ECG or

CAG), QT and QTc intervals were significantly longer in individuals with LVDD compared to individuals without LVDD⁵. QTc interval ≥ 435 ms had a sensitivity and specificity of 73 and 74%. Similar results were reported in patients with the suspicion of heart failure⁴. QTc prolongation can be attributed to many factors: altered intracellular calcium handling in cardiomyocytes, autonomic imbalance, or influences of comorbidities.

P Terminal Wave Duration And Height In Lead V1 And Morris Index:

P terminal wave duration as well as height were found to be significantly greater in LVDD in our study, similar to other studies (5,7). In left atrial enlargement, duration of terminal negative P wave deflection in lead VI ≥ 0.04 sec and amplitude of terminal negative P wave deflection in lead VI ≥ 0.10 mV.

Morris Index or P-wave terminal force in lead V1 (PTF-V1) is product of P terminal wave duration and amplitude in lead V1-normal value being <0.01 mm.s, in LAE it is ≥ 0.04 mm.s. PTF-V1 is an ECG marker of increased LA volume, elevated LA filling pressures and unfavorable LA remodeling as a consequence of atrial contraction against a stiffened LV. LIFE study found abnormal P-wave terminal force in lead V1 to be associated with worse diastolic function. Abnormal PTF-V1 values are related to left ventricular diastolic dysfunction, atrial fibrillation, congestive heart failure, stroke, and sudden death(8).

P-Wave Amplitude Lead2:

We found higher P wave amplitude in lead 2 in LVDD. Normal P wave amplitude in L2 is <2.5 mm or <0.25 mv. Hayiroglu et al measured amplitude of P-wave with LVDD as an outcome in 204 individuals without CAD or other major cardiac pathologies visiting the outpatient cardiology clinic⁸. At a cut-off value of 0.102mV, this parameter showed a sensitivity of 67% and specificity of 60%.

P wave duration Lead 2:

In our study, P wave duration in L2 was not significantly different between the groups ($p = 0.08$), probably due to small sample size. In a study by Sumita et al, P-wave duration > 110 ms was more sensitive for LVDD (sensitivity 86%, specificity 86%), and a P-wave duration > 120 ms was more specific for LVDD (sensitivity 34% and specificity 100%)¹⁰.

Strength and Limitations of our study:

Confirms reliability of abnormal P terminal force in lead V1 and utility of prolonged QTc in the diagnosis of LVDD. Limitations were small sample size and no distinction was made to account for gender in analyzing ECG variables, known to be gender-dependent (such as QT interval).

CONCLUSIONS

ECG is an widely available, relatively inexpensive investigation in primary care setting. Resting ECG parameters such as corrected QT interval, Morris Index, P terminal wave duration and amplitude in lead V1 and P wave amplitude in lead 2 were found to be significantly higher in patients with LV diastolic dysfunction. Hence, their identification helps in stratification of these patients for further investigations with a specialist, including echocardiogram with Tissue Doppler Imaging.

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