ORIGINAL ARTICLE

https://doi.org/ 10.3126/njms.v9i2.72550

Study of the Relationship between P-Wave Dispersion and Left Ventricular Diastolic Dysfunction in Patients presenting to a Tertiary Care Centre of Western Region of Nepal

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Received: April 01, 2024 **Accepted: June 15, 2024** **Published: July 31, 2024**

Cite this paper: Sapkota S, Paudel N, Kafle R, Guragain S, Tiwari A, Acharya CP, Yadav A. Study of the Relationship between P-Wave Dispersion and Left Ventricular Diastolic Dysfunction in Patients presenting to a Tertiary Care Centre of Western Region of Nepal. Nepal Journal of Medical Sciences, 2024;9(2):18:49-57. https://doi.org/ 10.3126/njms.v9i2.72550

ABSTRACT

Introduction: Left ventricular diastolic dysfunction (LVDD) leading to heart failure occurs when accompanied by a predominant or isolated abnormality in diastolic function in up to 50% of patients. Echocardiography remains primary investigation confirming diastolic dysfunction. This study emphasizes the use of P-wave dispersion (PWD) to assess and correlate with the diastolic dysfunction.

Methods: This is a cross-sectional descriptive study conducted in the Department of Medicine (Cardiology Unit), Manipal Teaching Hospital from September 2023 to February 2024. After obtaining ethical clearance from IRC, participants who had echocardiographic evidence of LVDD were studied. Relevant data were collected in a preformed pro forma and statistical analyses were carried out.

Results: Total 50 cases with 18 females and 32 males with mean age of 55.07±18.66 years was studied. There was strong association between increase in mean PWD with progression of LVDD from grade I to grade II, but not from grade II to grade III ($P > 0.05$). Progression of LVDD from grade I to grade III was associated with decrease in Left ventricular Ejection fraction (LVEF) (P value < 0.001). There was strong positive association between history of coronary artery disease (CAD) and increased PWD.

Conclusions: Increase in PWD was associated with increasing grades of LVDD. PWD can be used as a predictive marker for early progression of disease from Grade I to II unlike from grade II to III. Progression of LVDD from grade I to III was associated with decrease in LVEF. Positive history of CAD was a significant risk factor for increased PWD associated with LVDD.

Keywords: *Electrocardiography; LV diastolic dysfunction; P wave dispersion*

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INTRODUCTION

Left ventricular diastolic dysfunction (LVDD) leads to heart failure when it's accompanied by a predominant or isolated abnormality in diastolic function. [1,2] Echocardiography gives us diastolic function indicators like early-mitral filling velocity(E) and late-mitral filling velocity(A), E/A ratio, deceleration time and iso-volumetric relaxation time (IVRT). Electrocardiogram (ECG) is considered to be less yielding to assess the diastolic function dysfunction. [3]

P-wave dispersion (PWD) in ECG is defined as the difference in milliseconds between the longest and the shortest P wave duration in 12 lead ECG. PWD has been exclusively studied in many cardiovascular conditions and is an established non-invasive marker for risk of developing atrial fibrillation. [4] PWD has also been studied in hypertensive patients and a significant correlation was also shown with echocardiographic diastolic parameters. [5]

Studies from other regions show association of PWD with LVDD [6, 7] but little is known in emerging nations because of lack of population-based studies. [8] In this study, we evaluated patients with LVDD in echocardiography and studied its correlation with PWD in ECG.

METHODS

This was a cross-sectional descriptive study conducted in the Department of Medicine (Cardiology unit) of Manipal Teaching Hospital from September 2023 to February 2024. The approval for the study was taken from the Institutional Review Committee of Manipal. Written informed consent was taken from all the patients. Non probability convenience sampling technique was used. A total of 50 subsequent participants who had echocardiographic evidence of LVDD were included in the study. All of those who didn't have exclusion criteria were approached to participate in the study; those who were willing to provide informed written consent were included in the study. We excluded patients with thyroid dysfunction, uncontrolled diabetes mellitus, chronic liver/renal disease and severe electrolyte imbalance that may affect the P wave duration otherwise. We also excluded derivations from patients if the beginning or the ending of the P wave in electrocardiography was not clearly demarcated.

Echocardiographic data was extracted from routine transthoracic echocardiography reports performed at study site till the target sample size is achieved. All echocardiography in the study centre were performed by consultant cardiologists using commercially available system (VIVID T- GE healthcare). In all the patients the following diastolic function indicators were extracted; E and A velocities, E/A ratio, deceleration time. In addition, we also extracted LVEF (performed in our centre using Simpson's method), segmental wall motion defects, left atrial, left ventricular sizes and valves with 2-D echocardiography. To standardize the measurements, we ensured that the measurements were taken consistently, using the same procedural steps and methods and same echocardiographic settings and calibration.

Twelve lead ECG of all patients at rest with 10mm/mv and 25mm/sec were obtained however in few where P wave was not clear 20mm/ mv amplitude and 50 mm/ sec rate were also obtained. The beginning of the P wave was defined as the point where the initial deflection of the P wave crosses the isoelectric line and the end of P wave was defined as the point where the final deflection of P wave crosses the isoelectric line. If the beginning or the ending of the P wave couldn't be clearly identified the derivation was excluded. P-wave dispersion was calculated by

subtracting the minimum P wave duration from the maximum P wave duration. [9]

Data were analyzed using SPSS version 25. The qualitative data such as sex of the cases were analyzed using descriptive analysis for frequency. The variables with two categories such as whether LVDD, ischemic heart disease (IHD), valvular heart disease (VHD) was present or not were analyzed using Mann Whitney U test. The variables with three category LVDD grading (Grade I, II, III) were analyzed using One way ANOVA, if Homogeneity of variance test was positive > 0.05, Welch test was used if its negative. Post hoc (Gomes Howel) test was used to further evaluate the relation between variables > 3 categories.

RESULTS

This study analyzed total of 50 cases with 18 females and 32 males with mean age of 55.07±18.66 years. The clinical features, ECG and Echocardiographic findings of all the patients are presented in (Table 1 and 2).

Table 1: Age, Blood Pressure and Pulse rate (n=50)

	Over-all	Males	Females	P value
Mean age (yrs)	55.07 ±18.66	55.36 ±19.31	54.78 ±18.18	0.55
MeanSBP (mmHg)	130.04 ±19.56	132.04±21.16	128.04 ±17.82	0.60
MeanDBP (mmHg)	76.50 ±11.81	77.76 ± 9.86	75.24 ±16.90	0.55
Mean PR (bpm)	79.42 ±16.42	80.50 ±7.27	78.34 ±15.63	0.60

Table 2: ECG and echocardiography findings (n=50)

	Overall	Males	Females	P value
Mean Pmax (ms)	83.80±13.16	84.60 ± 14.02	83.00 ± 12.33	0.55
Mean Pmin (ms)	45.70± 12.89	45.20 ± 12.97	46.20 ± 12.91	0.10
MeanPWD (ms)	38.30 ± 9.86	39.60 ± 10.35	37.00 ± 9.60	0.15
MeanLVEF (%)	51.20 ± 9.40	50.90 ±10.18	51.50 ±8.64	0.55

Among these patients, different grading was done as grade I, II, III and the Patient's Age, Blood pressure, Pulse Rate, ECG finding and Echocardiographic finding is presented in (Table 3 and 4).

Table 3: Age, Blood Pressure and Pulse rate in different grades (n=50)

	Grade I	Grade II	Grade III	P value
Mean age (yrs)	53.12	52.75	67.50	0.065
Mean SBP (mmHg)	129.53	143.75	131	0.10
Mean DBP (mmHg)	75.65	86.55	78.50	0.55
Mean PR (bpm)	79.03	73.50	80.25	0.10

Table 4: ECG and ECHO findings in different grades (n=50)

	Grade I	Grade II	Grade III	P value
Mean Pmax (ms)	81.47	85.00	97.5	<0.05
Mean Pmin (ms)	47.94	35.00	43.75	<0.05
Mean PWD (ms)	33.82	50.00	53.75	<0.001
Mean LVEF (%)	55.14	43.75	40.00	<0.001

Statistically, there was no significance (p>0.05) of SBP, DBP and PR of patient with different grades of LVDD. There was observable difference in age of patient among patient having various grades of LVDD i.e. with increasing age of patient more severe or advance grading of LVDD was seen. However, it was statistically insignificant (p = 0.065).

There was statistically significant difference seen with Pmax, Pmin and different grading of patient with p value < 0.05 as illustrated in Table 4 i.e. increase in value of Pmax was associated with severe or advance grading of LVDD. However, decrease in value of Pmin was associated with progression of LVDD from grade I.

There was strong association between PWD and LVDD grading i.e. increase in PWD was associated with severe or advance grading of LVDD (P<0.001). For further evaluation of PWD with LVDD grading post hoc test was done. The result illustrated in (Table 5).

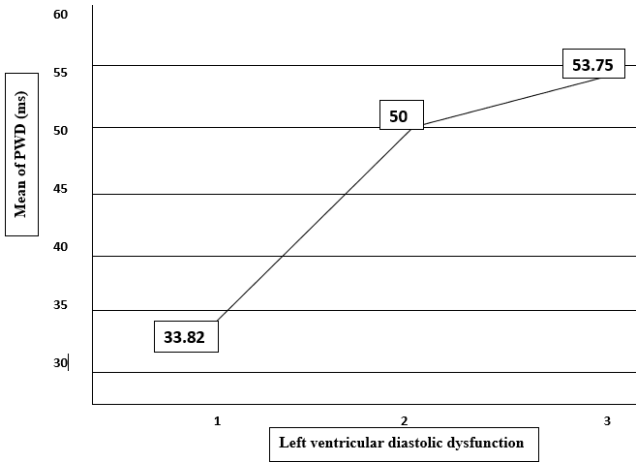
Table 5: Post hoc test (Gomes Howel) showing relation between PWD with various grade of LVDD (n=50)

Test variable 1	Remaining test variable	Mean difference of PWD (ms)	P value
Grade I	Grade II	-16.18	<0.001
	Grade III	-19.26	<0.001
Grade II	Grade I	16.18	<0.001
	Grade III	-3.75	0.060
Grade III	Grade I	19.26	<0.001
	Grade II	-3.75	0.075

As illustrated in Table 5, there was strong association between increases in mean PWD with progression of LVDD from grade I to grade II. However, there was no significant association between increase in mean PWD and progression of disease from Grade II to Grade III (P > 0.05). Thus, PWD can be used as a predictive marker for early progression of disease from Grade I where as it was not so strong association with increase in PWD with late progression of LVDD from grade II to grade III.

This can be seen in the (Figure 1), where mean increase in PWD was 16.18 with progression of LVDD from grade I to grade II whereas there was only increase of 3.75 in mean PWD with progression of LVDD from grade II to grade III.

Figure 1: Mean plot of PWD with different grades of LVDD (n=50)



There was also strong association with LVEF and different grades of LVDD i.e. progression of LVDD from grade I to grade III was associated with decrease in LVEF (P < 0.001).

Table 6: Age, BP, PWD and LVEF with history of CAD (n=50)

	History of CAD	No History of CAD	P value
Mean age(yrs)	59.29 ± 13.48	53.83 ± 21.12	0.10
SBP (mmHg)	132 ± 19.84	132.06 ± 21.92	0.55
DBP (mmHg)	77.57 ± 9.86	77.83 ± 12.62	0.60
PWD (ms)	47.86 ± 9.75	36.39 ± 9.90	< 0.001
LVEF (%)	38.21 ± 7.49	55.83 ± 5.91	<0.001

Table 7: Age, BP, PWD and LVEF with history of VHD (n=50)

	History of VHD	No History of VHD	P value
Mean age(yrs)	50.94 ± 21.67	57.44 ± 18.06	0.15
SBP (mmHg)	131.25 ± 19.14	132.41 ± 22.31	0.10
DBP (mmHg)	76.25 ± 13.38	78.24 ± 11.19	0.55
PWD (ms)	38.75 ± 10.88	40 ± 11.28	0.10
LVEF (%)	53.12 ± 6.29	49.85 ± 11.51	0.08

There was strong positive association between positive history of CAD and increased PWD and reduced LVEF (P < 0.001) for both of the variables among patients with LVDD irrespective of the group. However, there was no positive association between positive history of VHD and increased P wave dispersion (PWD) among LVDD patients. (p > 0.05) as shown in Table 7. Thus, positive history of CAD is a significant risk factor for raised PWD associated with LVDD but VHD is not.

DISCUSSION

P-wave dispersion is the difference between the maximum and minimum P-wave durations recorded on an ECG. Diagnosis of diastolic dysfunction is important for early diagnosis, follow-up, treatment, and prognosis evaluation in heart failure patients [10, 11] as diastolic function usually declines before systolic function, and this precedes clinical signs. P Wave Dispersion is related to the non-homogenous and interrupted conduction of sinus impulses intra and inter-atrially. Echocardiography gives us many diastolic

function indicators like E and A velocity, E/A ratio, deceleration time and iso-volumetric relaxation time. False normalization patterns can also be looked for by applying the valsalva maneuver, checking pulmonary blood flow and performing tissue Doppler Echocardiography. P Wave Dispersion has been found to be a non-invasive marker that correlates with left ventricular end-diastolic pressure (LVEDP) and other echocardiographic markers of diastolic dysfunction. This means that higher P wave dispersion values can indicate increased LVEDP, which is a sign of diastolic dysfunction [12]. Various diastolic function indicators or parameters are being used to assess the diastolic function in different patients. However, in the literature, few studies investigate the relationship between P Wave Dispersion and each grade of Left Ventricular Diastolic Dysfunction. [12] P Wave Dispersion as a predictor of atrial fibrillation has already been studied in several studies [4, 13-15]. The heterogeneous pattern of propagation of electrical activity through the atria was emphasized in one study because of scar tissue accumulation in hypertensive patients who have diastolic dysfunction. Longer P Wave Dispersion duration correlated significantly with the parameters of impaired diastolic function in the same study, [16] which was similar to the findings that we got in our study. As Left Ventricular Diastolic Dysfunction progresses from an “impaired relaxation” pattern to a restrictive pattern, increases in left atrial pressure and dimensions are expected. In our study, we used transthoracic echocardiography to measure diastolic function variables and then compared the P Wave Dispersion values of Left Ventricular Diastolic Dysfunction patients. There is strong association between increases in mean P Wave Dispersion with progression of Left Ventricular Diastolic Dysfunction from grade I to grade II. However, there was no significant association between increase in mean P Wave Dispersion and progression of disease from grade II to grade III. This finding was similar to the study published in 2005[12]. Studies have shown a significant positive correlation between P wave dispersion and markers of diastolic dysfunction such as left atrial volume (LAV) and left atrial diameter (LAD). [12] This suggests that as diastolic dysfunction worsens, P wave Dispersion tends to increase, making it a useful tool for assessing the severity of diastolic dysfunction in patients with coronary artery disease. Increase in P Wave Dispersion is directly associated with increase in Left Ventricular Diastolic Dysfunction in patients with history of Coronary Artery Disease These findings were similar to the findings of previous studies [17]. In contrary to the findings in patients with coronary artery disease, in patients with Valvular Heart Disease there was no association between Left Ventricular Diastolic Dysfunction with P Wave Dispersion in our study. However, unlike our findings one study found that P Wave Dispersion was useful in predicting Left Ventricular Diastolic Dysfunction even in patients with Valvular Heart Disease and can also indicate the risk of atrial arrhythmias in those patients [18]. These differences could be because of small sample size of our study and small number of people representing those groups. As cardiac function deteriorates, the left atrium often undergoes structural and electrical remodeling. This remodeling can lead to increased atrial pressure and volume, contributing to greater heterogeneity in atrial conduction, which is reflected as increased PWD. So, with the decrease in ejection fraction, the left ventricle's ability to pump blood effectively is compromised, leading to increased left atrial pressure and volume.[19] This increased atrial pressure and volume exacerbate atrial conduction abnormalities, resulting in a gradual increase in P Wave Dispersion. In our study also there was strong direct association with decrease in Left ventricular ejection fraction and

increment in grades of Left Ventricular Diastolic Dysfunction. While P Wave Dispersion is primarily linked to diastolic function, it can also provide insights into overall cardiac function. In patients with heart failure with preserved ejection fraction, P wave dispersion tends to be higher due to the impaired relaxation and increased atrial pressure [20]. P Wave dispersion increased significantly from Grade I to Grade II, but the difference was not as pronounced from Grade II to Grade III. This could be because P wave Dispersion depends on the change in left atrial size, mass of tissue excited and conduction,[21] so these values may not increase proportionately in between grades of diastolic dysfunction. Hence P Wave Dispersion can be used as a predictive marker for early progression of disease but it doesn't significantly predict the late progression. The ability to use P Wave Dispersion as a marker for Left Ventricular Diastolic Dysfunction is particularly valuable in clinical settings where more invasive measures of assessing diastolic function are not feasible. It provides a simple, cost-effective method for early detection and monitoring of diastolic dysfunction, which can help in the timely management of patients with heart disease. Our sample size was small and there were possibilities of inter and intra observer variability in measurement of variables. Similarly, P wave dispersion could also have been affected by drugs like antihypertensives and antiarrhythmics [22]. The study was carried out in a single tertiary centre. The change in P wave dispersion by these sorts of drugs was not taken into consideration in our study. The possibility of selection bias due to the convenience sampling method couldn't be avoided. These were some of the limitations of our study. This indicates the need for larger studies to further validate its utility and to explore whether P Wave Dispersion can be integrated into routine clinical practice for better risk stratification and management of patients with Left Ventricular Diastolic Dysfunction. However, the relationship between P-wave dispersion and left ventricular diastolic dysfunction highlights the potential of electrocardiography-based markers in the non-invasive assessment of heart conditions. Continued research in this area could lead to improved diagnostic and prognostic tools, ultimately not only enhancing patient care but also for early detection of patients with diastolic dysfunction so that treatment can be initiated earlier.

CONCLUSIONS

Increase in P Wave Dispersion was associated with severe or advance grading of Left Ventricular Diastolic Dysfunction. P Wave Dispersion can be used as a predictive marker for early progression of disease from Grade I where as it was not so strong association with increase in P Wave Dispersion with late progression of Left Ventricular Diastolic Dysfunction from grade II to grade III. Progression of Left Ventricular Diastolic Dysfunction from grade I to grade III was associated with decrease in LVEF. Positive history of CAD is a significant risk factor for raised P Wave Dispersion associated with Left Ventricular Diastolic Dysfunction but VHD is not. Hence P wave dispersion is not only the, simple, easy procedure to perform and interpret but also a convenient, non-invasive tool that can be used in day-to-day practice for early detection of LV diastolic dysfunction in a cost-effective manner.

CONFLICT OF INTEREST

None

SOURCES OF FUNDING

None

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