Left Ventricle Diastolic Wall Strain as a Simple Parameter of In-hospital Mortality in Heart Failure with Reduced Ejection Fraction (HFREF) Patients

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ABSTRACT

Background: Abnormality of Left ventricle (LV) relaxation and LV stiffness are the major parts of LV diastolic dysfunction which have an important role in heart failure patients. Left ventricle Diastolic wall strain (DWS) is a non-invasive, load-independent, and reproducible estimator of LV stiffness using 2-D echocardiography based on linear elastic theory. Some studies have revealed the robust role of LV stiffness in heart failure with preserved ejection fraction (HFPEF) patients, but role and prognostic value of this parameter remains unclear in HFrEF.
Methods: We studied 40 patients with signs and symptoms of heart failure (EF < 50%) between September to December 2017. Patients with the history of cardiac surgery, moderate to severe valvular heart disease, atrioventricular block, constrictive pericarditis, atrial fibrillation and old myocardial infarction in posterior wall are excluded. DWS was measured using the formula: DWS = [(LV posterior wall thickness at end systole − LV posterior wall thickness at end-diastole)/LV posterior wall thickness at end-systole]. All patients diverged into 2 groups (with and without in-hospital mortality) and DWS results were compared.
Results: A total of 40 patients, 9 females (22%), with average age 59.6 ± 9.38 years. Hypertension in 18 patients (45%), type 2 Diabetes 22 patients (55%), Dyslipidemia 27 patients (67%). We found 14 patients (35%) with mortality in hospitalization. E/A ratio, E/E' and DWS were significantly associated with in-hospital mortality. Between groups, DWS was significantly lower in patients with in-hospital mortality by 0.14 ± 0.09 vs 0.22 ± 0.08 (P = 0.008). Although it is not statistically significant, lower DWS conversely related to diastolic dysfunction severity.
Conclusion: DWS is associated with more severe outcome in HFrEF patients. As a simple and non-invasive parameter of LV stiffness, DWS can be useful to predict poor prognosis of HFrEF patients.
Keywords : DWS, Diastolic dysfunction

Background:

Heart failure (HF) is a global health issue that affect about 26 million people worldwide[1]. Over decades, The prognosis for HF has been improving due to advances in pharmacologic therapy, but half of people diagnosed with HF will suffer death within 5 years[2]. Myocardial stiffness of LV is one of the key elements of diastolic function and has been studied in cross sectional studies of both HF with reduced ejection fraction (HFrEF) and HF with preserved EF (HFpEF)[3,4]. However, there are only few studies that investigate the relationship between LV myocardial stiffness and HF incidence mostly due to difficulty of evaluating myocardial stiffness. Evaluating LV myocardial stiffness requires invasive procedures and complicated measurements[5].

LV Diastolic wall strain (DWS) is a non-invasive, load-independent, and reproducible parameter of LV stiffness using 2-D echocardiography based on theory of linear elastic. It is an extension of the linear elastic theory which conveys that decreased wall thinning in diastolic phase reflects decreased compliance and distensibility of the LV, and thus, will increase the LV stiffness[6]. This parameter was found to have prognostic impact in worsened outcome[3], in Heart failure reduced ejection fraction (HFrEF)[7], and Heart Failure Preserved Ejection Fraction (HFpEF)[4] . Patients with Heart failure mid-range ejection fraction (HFmrEF), have predominantly mild systolic dysfunction, and associated with of diastolic dysfunction state[8].

Some studies have shown the importance of LV stiffness in heart failure with preserved ejection fraction (HFPEF), but its role and prognostic value in HFrEF patients remains unclear. Therefore, we sought to study the relationship between LV DWS and prognosis of our HFrEF patients during the treatment in the hospital.

Methods

We conducted a cross-sectional study that included patients with signs and symptoms of heart failure with Ejection Fraction < 40 % based on echocardiographic measurements between September- December 2017 at Adam Malik General Hospital. We did the data collection through anamnesis, physical and laboratory examination, Electrocardiography, and echocardiography. The demographics of all patients, including age, sex, hypertension, type II diabetes mellitus, and dyslipidemia) were recorded. Exclusion criterias are history of cardiac surgery, moderate or severe valvular heart disease, atrial fibrillation, constrictive pericarditis, atrioventricular block and old posterior myocardial infarction. Written informed consent was obtained from the patients before the study. The protocol of this study was approved by the institutional ethics committee.

Echocardiographic measurement

All echocardiographic data were obtained during sinus rhythm in both groups.
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DWS was measured using the formula: DWS = [(LV posterior wall thickness at end systole − LV posterior wall thickness at end-diastole)/LV posterior wall thickness at end-systole]. Several echocardiographic characteristics such as left atrial size, LV end diastolic diameter, LV wall thickness, were determined from M-mode echocardiography.
The peak velocities of early (E) and late (A) filling waves, the E/A ratio of peak velocities, and the deceleration time of the E-wave were measured from transmitral flow velocities. The early diastolic mitral annular velocity of the septal and lateral mitral annulus (e' velocity) was obtained by tissue Doppler imaging and the E/e' ratio was also calculated. We also divided the patient into 3 groups based on the diastolic dysfunction severity , and evaluated the relationship between DWS and severity of diastolic dysfunction.

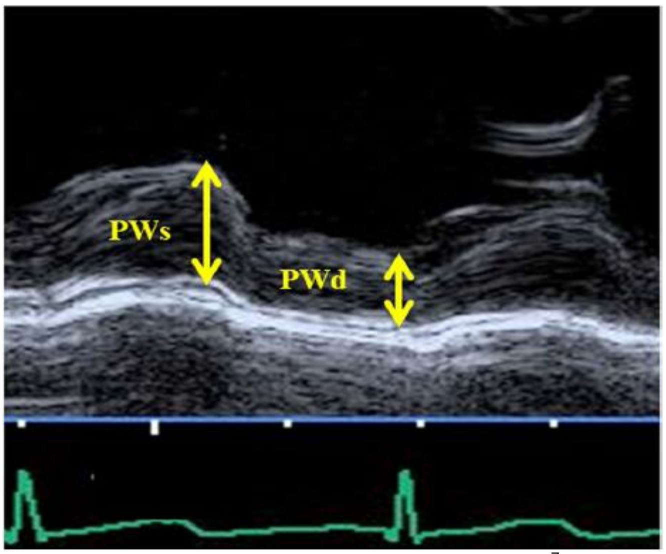

Figure 1. DWS measurement on echocardiography[7]

DWS = (PWs − PWd)/PWs

DWS : Diastolic Wall Strain
PWs : Posterior wall thickness (systole)
PWd : Posterior wall thickness (diastole)

Follow up
We did follow up investigation to all patients during the HF treatment in the hospital then the patients were divided into 2 groups (with and without in-hospital mortality) and DWS was compared between groups. The follow-up period was the time from the date of echocardiography to the date of the events.

Statistical Analysis
Data of categorical variables were presented as the number or frequency (n) and percentage (%). Continuous variables were presented as mean and the standard deviation (SD). Categorical variables were analyzed by using Chi-squared ($\chi 2$) and Fisher's exact test and continuous variables by Independent T or Mann-Whitney test. Normality test was done by using one sample Kolmogorov-Smirnov (n >50) or the Shapiro-Wilk (n <50). P-value < 0,05 is considered to be significant. All statistical analysis were measured using the SPSS software for Windows.

Results
Patients characteristics
58 patients were enrolled in our study, 18 patients were excluded from this study because of history of cardiac surgery (n = 4), moderate to severe valvular heart disease (n = 6), atrioventricular block (n = 1), atrial fibrillation (n = 3), and old myocardial infarction in posterior wall (n = 4).
A total of 40 patients, 9 females (22%), mean age 59.6 ± 9.38 years. Hypertension was found in 18 patients (45%), type 2 Diabetes mellitus 22 patients (55%), Dyslipidemia 27 patients (67%). 14 patients (35%) suffered death during treatment. Patients who suffered death during hospitalization were older in age, although the difference between these groups was not significant. From these baseline characteristics, we also found that the patients in mortality group were predominantly accompanied by hypertension and type 2 DM comorbidities.

Table 1. Baseline Characteristics

Parameters	Mortality (-) (n=26)	Motality (+) (n=14)	P-Value
Age (yrs)	58,6 ± 9,4	61,5 ± 4,7	0,36
Female, n (%)	7 (27%)	2 (14%)	0,9
Hypertension, n (%)	10 (38%)	8 (57%)	0,26
Type 2 DM, n (%)	12 (46%)	10 (71%)	0,13
Dyslipidemia, n (%)	18 (69%)	9 (64%)	0,75

Echocardiographic results between groups

Between two groups measurement, DWS was significantly lower in patients with in-hospital mortality by 0.14 ± 0.09 vs 0.22 ± 0.08 (P = 0.008). Our results showed E/A ratio, E/E' and DWS were significantly associated with in-hospital mortality. Patients who suffered death on the time of hospitalization had significantly lower DWS compared to other group. Deceleration Time (DT), as one of the diastolic parameters on echocardiography, exhibited no statistically significant difference on both groups.

Table 2 Echocardiographic Characteristics

Parameters	Mortality (-) (n=26)	Motality (+) (n=14)	P-Value
LVIDd,mm	55,6 ± 5,9	57,2 ± 6,6	0,37
LA, mm	36,6 ± 7,6	37,2 ± 6,4	0,83
LV Mass, g	271,2 ± 5,7	276,2 ± 7,9	0,82
DT	166,2 ± 5,3	156,5 ± 3,3	0,72
E/A ratio	1,09 ± 0,5	1,55 ± 0,9	0,04
E/E'	9,7 ± 3,2	13,6 ± 4,7	0,01
DWS	0,22 ± 0,08	0,14 ± 0,09	0,008

LVIDd = Left Ventricular Internal Diameter end diastole; LA=Left Atrial;
LV = Left Ventricle; DT=Deceleration Time; DWS=Diastolic Wall Strain

Diastolic wall strain and diastolic dysfunction

We also compare DWS according to the severity of diastolic dysfunction. Diastolic dysfunction divided into 3 groups. The worse diastolic dysfunction exhibited significantly higher E/A ratio and E/E' ratio. Although it is not statistically significant, lower DWS conversely related to diastolic dysfunction severity based on echocardiography.

Table 3 Diastolic Dysfunction Parameters

Parameters	DD 1 (n=20)	DD 2 (n=14)	DD 3 (n=14)	P-Value
E/A ratio	0,8 ± 0,2	1,3 ± 0,3	2,6 ± 0,4	0,001
E/E'	8 ± 1,8	12,7 ± 1,9	17,1 ± 5,1	0,001
DWS	0,2 ± 0,08	0,17 ± 0,1	0,15 ± 0,1	0,149

Discussion

In our study, the patients with lower DWS had higher rate of mortality than those with higher DWS, suggesting that DWS could predict the worse outcome in HFrEF patients. DWS can conversely be thought of as a wall thickening index, not just wall thinning, and may therefore help to measure systolic function of the LV. Theoretically, DWS should correlate well with radial strain, which is itself a systolic index. That DWS may actually correlate well with both systolic and diastolic indices suggests, in fact, that DWS is rather an overall marker of myocardial performance and health[9].

We also found that DWS is conversely related to diastolic dysfunction severity, but the result was not statistically significant. This finding also supported by previous study that revealed no correlations between DWS and other parameters of diastolic dysfunction[7].

Diastolic wall strain (DWS) is the estimation of LV stiffness according to linear elastic theory, which could predict that impaired diastolic wall thinning reflects resistance to deformation in diastole, thus it also indicates increased LV stiffness[8]. Previous study also conducted multivariate analysis and found that DWS was the independent predictive factor of worse outcome. Moreover, impaired LV stiffness is associated with worse prognosis in HFrEF[7].

DWS is an useful parameter to predict the poorer outcome because it might reflect the myocardial stiffness of LV myocardium. It is important for the physicians to be able to stratify heart failure patients according to groups with the highest risk for hospitalization because consider another medical strategy or non-pharmacotherapy could be applied to this patient population. DWS evaluation should be taken into consideration in HFrEF treatments because this measurement is within the capacity of any clinical laboratory and applicable to any patients in our daily practice[7].

Impaired LV relaxation and increased LV diastolic stiffness are the major components of diastolic dysfunction. In the other hand, The DWS was weakly correlated with E/A ratio and did not correlate well with mitral early and late filling ratio (E/A ratio) in HFpEF patients[10]. According to another study, in patients with HFrEF, DWS did not correlate with plasma BNP level, LVEF, E′, DT and E/A[7]. In our study, we found that lower DWS conversely related to diastolic dysfunction severity based on echocardiographic measurements, but this relationship was not statistically significant.

Conclusions

Diastolic Wall Strain (DWS) is associated with worse outcome in HFrEF patients. DWS, as a feasible and non-invasive parameter of LV stiffness, can be useful to predict worse prognosis of HFrEF patients. Thus, measurement of DWS should be taken into our consideration for the HFrEF treatment.

Limitations of study

Smaller number of patients compared with previous studies was one of the study limitations. Further, echocardiographic measurement should included more parameters of systolic and diastolic function. In the future, further study with larger number of patients will be needed, to be resulting in better analysis of the relationship between the DWS and many other parameters of heart failure patients.

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