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Original Article

Comparison of Doppler Echocardiography and Tissue Doppler Imaging in the Assessment of Left Ventricular Filling Pressure

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Abstract

Background*:** Diastolic dysfunction in patients with congestive cardiac failure contributes to a significant mortality and morbidity. The present study has been envisaged to determine the accuracy of TDI findings with Doppler echocardiography in determining the left ventricular filling pressure. ***Materials and Methods: Tissue Doppler imaging was performed for Ea, Em, E/Ea, deceleration time (DT) measurements. These variables were analyzed individually, as the average of the medial and lateral annulus, and as the maximum of the medial and lateral annulus. Tests of diagnostic accuracy were applied for significant variables.. ***Results*:** A total of 100 consecutive patients were enrolled of which 82 had angina and 18 had congestive cardiac failure. Comparison of various Doppler parameters in the study participants revealed a significant correlation between DT and LVEDP (r = 0.52) in patients with EF $\leq$ 50 but not in those with EF > 50% (r =0.18). E/Em medi-al annulus had a sensitivity of 90.9 % [95% CI -78, 97] and specificity of 89.28% [95% CI-78, 95) with a PPV of 86.95 % [95% CI-73, 95] and NPV = 92.59 % [95% CI-82, 97] of predicting LVEDP as compared to individuals with a raised LVEDP. The areas under the curves were 0.82 and 0.75 for the medial and lateral annulus, respectively. ***Conclusions*:** The present study shows that the E/Em ratio shall perform as a good initial measure while estimating of left ventricular filling pressures, particularly in those patients with preserved systolic function.

Keywords: Diastolic dysfunction, Doppler echocardiography , E/Em ratio, systolic function.

Introduction

Diastolic dysfunction contributes significantly to the symptoms and signs in congestive cardiac failure. Widely used technique for measurement of diastolic function of left ventricle is Doppler echocardiography. [1] Mitral inflow velocity curve is a surrogate marker of left ventricular filling pressure but the technique is sensitive only in patients with systolic dysfunction.[2] Some of the important prognostic factors for diastolic function include peak myocardial early diastolic velocity measured at the mitral annulus (Ea), myocardial segments (Em) and measurement of transmitral to tissue Doppler imaging (TDI) early diastolic velocity ratio (E/Ea) of which Em has been determined to be the strongest risk factor of mortality.[3] The present study has been envisaged to determine the accuracy of TDI findings with Doppler echocardiography in determining the left ventricular filling pressure.

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Materials and Methods

The study was conducted in a private teach -ing hospital between Aug 2012 and Dec 2013 after obtaining permission from. The institutional ethics committee and written informed consent from all the study participants. Doppler echocardiography was performed by a physician who was trained in doing the procedure for the past 2 years with a level 3 training. TDI of the mitral annulus was also performed by the same physician from the apical fourchamber view. Analysis was performed for Ea, Em, E/Ea, deceleration time (DT) measurements. These variables were analyzed individually, as the average of the medial and lateral annulus, and as the maximum of the medial and lateral annulus. All the numerical variables were tested for normality and paired t test was applied. Descriptive statistics was used to represent the numerical varia-

bles by mean (SD). Chi-square test was applied for analyzing the categorical variables. A receiver operating characteristics (ROC) was employed between the conventional and TDI findings. The sensitivity, specificity, positive (PPV) and negative (NPV) predictive values with 95% confidence intervals (CI) of Diagnostic measures were assessed with a cut-off value of LVEDP of 12 mm Hg. From the conventional Doppler readings, E/A > 2, DT < 130 ms, PVa > 30ms longer than MVa duration were compared for the prediction accuracy of LVEDP > 12 mm Hg. A p value of $\leq$ 0.05 was considered significant.

Demographics: A total of 100 consecutive patients were enrolled during the said time period. Mean (SD) age of the study participants was 56.9 (10.1) years. Four-fifth of the study participants were males and 82 study participants were referred for evaluation of angina while the remaining individuals had congestive cardiac failure. Of the 18 patients, 12 (66.7%) had left ventricular dysfunction and 34/100 had EF < 50%. Of the study participants, 38% were diabetic, 40% hy-pertensive and 18% had prior myocardial infarction. Mitral and TDI signals were fused in four and two patients respectively.

Conventional Doppler measurements: Correlation co-efficient of left ventricular end diastolic pressure (LVEDP) between patients with ejection fraction (EF) > and $\leq$ 50 with conventional Doppler is depicted in Table 1. Comparison of various Doppler parameters in the study participants revealed a significant correlation between DT and LVEDP (r = 0.52) in patients with EF $\leq$ 50 but not in those with EF > 50% (r =0.18). Similarly, the E/A ratio was better correlated with LVEDP when EF was $\leq$ 50% (r = 0.45) than when EF was > 50% (r = 24). IVRT also correlated with EF $\leq$ 50 (0.58) and not in patients with EF > 50 (r=0.20).

TDI measurements: The measurements of various parameters by TDI are depicted in Table 1. The correlations of medial annulus TDI were consistently equivalent or better than the lateral annulus or the combinations of the medial and lateral annulus. E/Em medial annulus had a sensitivity of 90.9 % [95% CI -78, 97] and specificity of 89.28% [95% CI-78, 95) with a PPV of 86.95 % [95% CI-73, 95] and NPV = 92.59 % [95% CI-82, 97] of predicting LVEDP as compared to individuals with a raised LVEDP. Similarly, E/Em lateral annulus had a sensitivity of 88.63 % [95% CI-75, 96], specificity of 77.77% [95% CI-64, 87] and PPV of 76.47 % [95% CI -62, 87] with NPV of 89.36 % [95% CI-76, 96].

Table 1. Echocardiographic and TDI findings in the study participants.

Parameters	Mean ± SD	Patients with EF < 50 (n=34) (mean ± SD)	Patients with EF > 50 (n=66) (mean + SD)
EF	50.12 ±10.26	39.12 ±10.48	55.79 ±2.96*
LVEDP	12.26 ±3.83	13.59 ±3.92	11.58 ±3.63*
E	75.13 ±17.47	75.45 ±21.10	74.98 ±15.44
A	78.58 ±19.59	88.06 ±18.22	73.70 ±18.58
MV-a	180.76 ±41.16	178.35 ±40.67	182 ±41.67
E/A	1.03 ±0.44	0.9 ±0.4	1.09 ±0.45
IVRT	93.22 ±18.33	96.59 ±19.08	91.64 ±17.84
Em medial annulus	6.67 ±2.22	5.63 ±1.78	7.21 ± 2.24*
Em lateral annulus	8.71 ±2.53	7.29 ±1.85	9.36 ±2.49*
Am medi- al annulus	9.39 ±1.94	9.36 ±2.49	9.41 ±1.61
Am lateral annulus	11.49 ±2.78	11.09 ±3.51	11.69 ±2.32
DT	198.36 ±41.14	204.24 ±57.4	195.33 ±29.62
LA volume index	22.77 ±4.55	24.36 ±4.07	21.95 ±4.66*
E/Em medial annulus	12.13 ±4.08	14.32 ±5.19	11.01 ±2.82*
E/Em lateral annulus	9.05 ±2.84	10.66 ±3.41	8.22 ±2.09*
PVa	177.40 ±30.9	197.41 ±31.29	167.09 ±25.30*
PVa-MVa	0.8 ±35.27	19.06 ±30.6	8.61 ±35.99*

*P < 0.05 between the sub-groups.

Comparison of TDI and conventional echocardiography measurements: The ROC curve for prediction of elevated LVEDP from the E/Em ratios are shown in Figure 1. The areas under the curves were 0.82 and 0.75 for the medial and lateral annulus, respectively. The best TDI parameter correlating with LVEDP was the E/ Em medial (r = 0.67) especially in patients with EF $\leq$ 50% (r =0.74) as compared to those with EF >50% (r = 0.41).

Comparison of Doppler parameters in predicting LVEDP > 12 mm Hg : All the four Doppler variables (E/A, DT, PVa-MVa, E/Em) were tested for their prediction of LVEDP > 12 mm Hg (Fig. 2). The E/Em had the highest pre-dictive accuracy of 71%.

Clinical application of Doppler methods: As E/Em had been found to have the highest predictive value, patients were classified with a value of < 8 (n=24), 8-15 (n=30) and > 15 mm Hg (n=47). A total of 84% of patients with E/Em < 8 had normal LVEDP while 92% with E/Em > 15 had elevated LVEDP. In the intermediate group (E/Em between 8 and 15) PVa- MVa > 30 msec was better associated with a higher filling pressure. On the other hand, left atrial volume index (LAVi) failed to determine even the milder forms of diastolic dysfunction (sensitivity-98%, specificity-14.28%, PPV-42.82%, NPV-98%).

Fig 1. ROC for prediction of LVEDP > 12 mmHg using E/Em at both septal and lateral annulus.

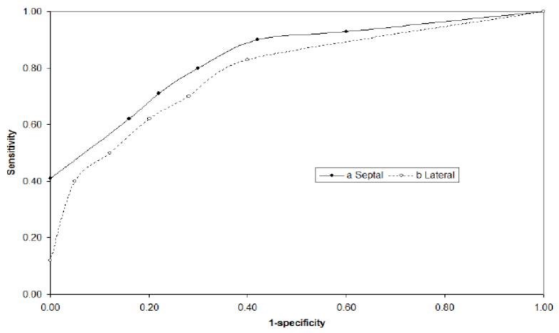
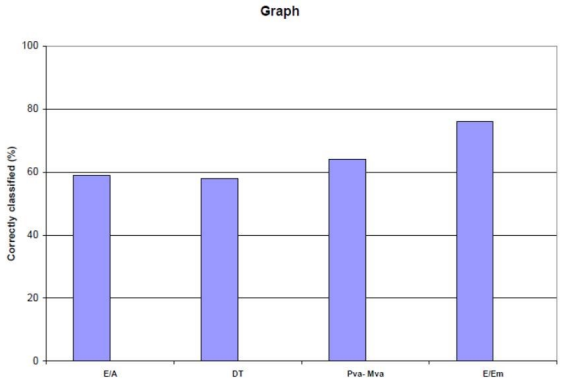


Fig 2. Comparison of various Doppler variables in predicting LVEDP > 12 mm Hg



Discussion

The present study evaluated the diagnostic accuracy of TDI with conventional Doppler echocardiographic findings in patients with angina or congestive cardiac failure. We found that TDI was technically better than conventional Doppler in receiving signals and E/Em medial annulus ratio as the single best predictor of left ventricular filling pressure with a sensitivity of 90.9% and specificity of 89.28%. In patients with EF $\leq$ 50%, both DT and E/A ratio were significantly correlated than in patients with EF > 50%. On the other hand, in patients with a raised left ventricular filling pressure, PVa-MVa > 30 msec had a sensitivity of 90.9% and specificity of 73.21%.

The findings of the present study were similar to previous studies that had evaluated a similar hypothesis.[4-6] Assessment of the left ventricular filling pressure is an important clinical tool in the assessment of left ventricular function and transmitral flow velocities have been shown to be useful in patients with left ventricular systolic dysfunction while not in those with a preserved function. Hence, transmitral flow velocity parameters along with annular velocity are found to be the best parameter determining the left ventricular filling pressure in our study which is corroborating the results of other studies.[4-6] However, E/Em is significantly scattered especially in patients with intermediate values. Further considering the variability of relaxation of relaxation of left ventricle in patients with coronary artery disease this parameter may further be confounded. TDI is easier to obtain and in the present study it is found to be having a good accuracy rate than other methods that are used for determining left ventricular filling pressures. A good and analysable tissue signal was obtained in 98% of patients and was fused in 2 % of cases.

The study is limited in not analyzing the parameters individually when the myocardium is undergoing contraction, rotation and translation; correction for the differences in the length of long axis was not performed. To conclude, the present study shows that the E/Em ratio shall perform as a good initial measure while estimating of left ventricular filling pressures, particularly in those patients with preserved systolic function.

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Confict of interest: The authors claim to have no conflict of interests in the context of this work.