Assessment of Left Ventricular Systolic Function Using Pulsed-Wave Systolic Mitral Annular Velocities (S_m): The Preliminary Results - Simple and Relevant

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Abstract

Background-.Echocardiography has evolved as a well-established part of the evaluation of global myocardial function. Tissue Doppler echocardiography is a novel technique with wide applications, including estimation of myocardial systolic function. We hypothesized that velocity time integral (VTI) of systolic mitral annular velocity had a better correlation with systolic function in comparison to peak velocity. Consequently, for the first part of our investigation, we selected a population with near normal systolic function to show initially the linear correlation and secondly to obtain the normal values.

Methods- We conducted a cross-sectional study at the echo lab with prospective simple non-random data collection on 50 consecutive patients (26 % normal, 38% CAD, 20% HTN, 10% MVP and 6% miscellaneous), mean age 45.6 yrs. (range: 18-80 yrs.) and 42% female. The exclusion criteria were prosthetic valves, LV systolic dysfunction, and/or severe regional wall motion abnormality, significant regurgitation (MR and/or AR), severe mitral annular calcification (MAC), non-sinus rhythm, paradoxical septal motion and poor endocardial line definition. All underwent complete echocardiographic study including TDI; some of the indexes of PW-TDI, with special attention to the systolic velocity of mitral annulus (Sm), were correlated with three different methods of EF measurement.

Results- The mean ejection fraction and VTI of Sm were 61.68% and 1.6594, respectively. Of TDI indices, linear regression analysis showed that VTI of Sm had the strongest statistical correlation with EF measured by Simpson's method (p=0.014, EF= 50.1 + 6.96 X VTI).

Conclusion- Despite some inevitable limitations, our preliminary data suggest that peak velocity and particularly VTI of Sm in PW-TDI can be considered as reliable, rapid and reproducible indicators of preserved LV systolic function. However, we are currently conducting another complementary study to compare PW-TDI of Sm in patients with LV systolic dysfunction with or without mitral regurgitation ***(Iranian Heart Journal 2007; 8 (3): 27-31).***

Key words: left ventricular systolic function ■ tissue Doppler imaging

Tissue Doppler imaging (TDI) represents a recent evolution of the Doppler technique and allows a quantitative measurement of myocardial velocities, providing a new frontier in the field of echo research. TDI provides important data in the analysis of

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myocardial function, both in diastole and systol To date, the greater contribution of TDI has been in the assessment of left ventricular diastolic function and filling pressures. [1]

On the other hand, evaluation of LV systolic function is one of the most common indications for performing echo in an outpatient or inpatient basis.[1,2]

However, standard methods are often limited by technical problems, inaccuracy and sometimes significant inter-observer and intra-observer discrepancies.[3] Some of the advantages of TDI are its ability to obtain information that is not completely dependent on the visibility of endocardial border and its relatively preload independence.[4]

Taken these data together, we sought to compare the conventional echocardiographic methods of LV systolic function assessment with mitral annular velocity indexes.

Methods

Study data

We carried out a cross-sectional study at our echo lab with prospective simple non-random data collection on 50 consecutive patients (26 % normal, 38% CAD, 20% HTN, 10% MVP and 6% miscellaneous) mean age 45.6 years (range: 18-80 yrs) and 42% female. Our exclusion criteria were patients with

1. Prosthetic valves
2. LV systolic dysfunction, and/or severe regional wall motion abnormality
3. Significant regurgitation (MR and/or AR)
4. Severe mitral annular calcification (MAC)
5. Non-sinus rhythm
6. Paradoxical septal motion
7. Poor endocardial line definition

After complete clinical assessment (history, physical examination and EKG), echocardiography was performed and all the pertaining data were recorded for off-line measurement by two experienced physicians unaware of the 2-D and TDI data.

Echocardiography

All the patients were examined at rest and lying in the left lateral position. The measurement was made using a prototype ultrasound system, Vivid 3 (GE Medical Systems, USA) with broad-based transducers and second harmonic facilities. The heart rate was measured at the time of study as well.

LV systolic function was measured by Simpson's and M-mode methods according to previously defined criteria by the American Society of Echocardiography.[2]

PW-TDI study was accomplished at the end-expiration or with quiet respiration to minimize the effects of respiration. In the four-chamber view, mitral annular velocities were recorded at the junctions of mitral leaflets with LV lateral wall and inferoseptal regions. Care was taken to align M-mode cursor so that the Doppler angle of incidence was as close to 0^o as possible.

The indexes were measured twice at each site and then the mean was recorded.

The following indexes were assessed:

- Peak velocity of Sm (cm/s)
- VTI of Sm (cm)
- Peak velocity of Ea (cm/s)
- Peak velocity of Aa (cm/s)

Data analysis

We analyzed the data using SPSS ver. 11.

Results

Ejection fraction (EF) measured by Simpson's method was highly correlated with M-mode method ($p=0.000$). MAPD was also another appropriate method with sufficient correlation with Simpson's, ($p=0.04$).

Of TDI indexes, linear regression analysis showed that VTI of S_m had the strongest statistical correlation with EF measured by Simpson's ($p=0.014$, $EF=50.1+6.96 \cdot VTI$).

Tables I and II show the data correlation with various parameters.

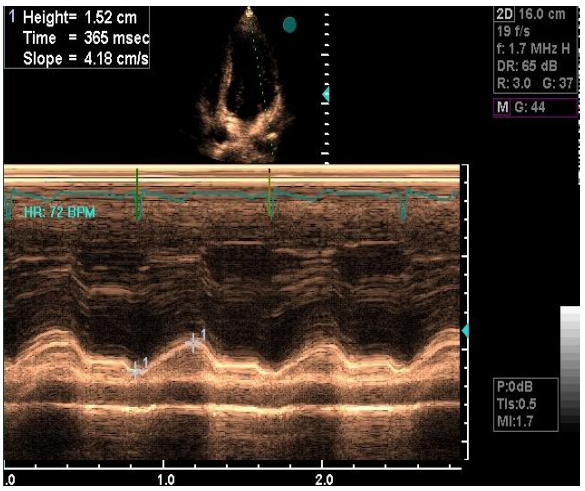

Fig. 1. Technique of MAPD measurement.

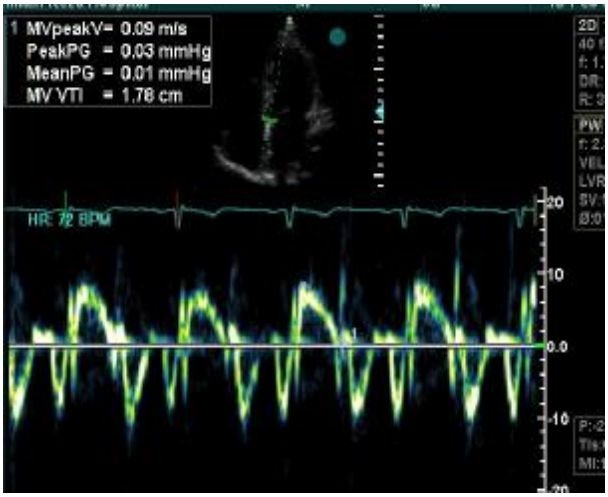

Fig. 2. TDI S_m VTI(s)

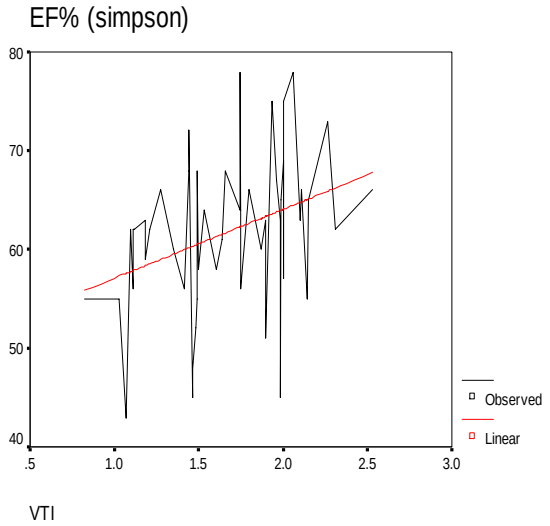

Fig. 3. Linear regression analysis.

Table I. Descriptive statistics of variables

	N	Min.	Max.	Mean	Std. Deviation
EF% (Simpson)	50	43.00	78.00	61.6800	7.93453
EF% (M mode)	50	42.00	84.00	64.0600	9.84660
MAPD	50	1.15	2.30	1.5876	.26233
S (PV)	50	4.50	15.25	8.2750	2.14895
E (PV)	50	3.56	20.92	11.3796	4.22416
A (PV)	50	5.09	16.35	9.6638	2.59548
VTI Sm	50	.82	2.53	1.6594	.39356
Valid N (list wise)	50				

Table II. Pearson correlations of different variables

		EF% (Simpson)	EF% (M-mode)	MAPD	S	E	A	VTI
EF% (Simpson)	Pearson Correlation	1.000	.708	.251	.269	.226	-.088	.345
	Sig. (2-tailed)	.	.000	.079	.059	.115	.543	.014
	N	50	50	50	50	50	50	50
EF% (M Mode)	Pearson Correl.	.708	1.000	.224	.316	.254	.060	.347
	Sig. (2-tailed)	.000	.	.118	.025	.075	.679	.014
	N	50	50	50	50	50	50	50
MAPD	Pearson Correlation	.251	.224	1.000	.218	.273	.072	.329
	Sig. (2-tailed)	.079	.118	.	.128	.055	.621	.020
	N	50	50	50	50	50	50	50
S	Pearson Correlation	.269	.316	.218	1.000	.542	.505	.745
	Sig. (2-tailed)	.059	.025	.128	.	.000	.000	.000
	N	50	50	50	50	50	50	50
E	Pearson Correlation	.226	.254	.273	.542	1.000	-.082	.804
	Sig. (2-tailed)	.115	.075	.055	.000	.	.574	.000
	N	50	50	50	50	50	50	50
A	Pearson Correlation	-.088	.060	.072	.505	-.082	1.000	.121
	Sig. (2-tailed)	.543	.679	.621	.000	.574	.	.402
	N	50	50	50	50	50	50	50
VTI	Pearson Correlation	.345	.347	.329	.745	.804	.121	1.000
	Sig. (2-tailed)	.014	.014	.020	.000	.000	.402	.
	N	50	50	50	50	50	50	50

Discussion

Assessment of LV systolic function is one of the most common indications for doing echocardiography. Feigenbaum et al. first described the use of ultrasound in 1967 to image the motion of mitral annular ring as a non-invasive measure of LV systolic function.[1]

As noted before, standard methods are often limited by technical problems, inaccuracy and poor reproducibility. One of the distinct advantages of TDI is its ability to obtain information that is not completely dependant on the visibility of the endocardial border.

Measurement of several annular sites has been shown to have good correlation with LVEF. Gulati and Nagueh reported a good correlation between S2 and EF. These data are also compatible with our findings, which suggest that, in carefully selected patients, the peak velocity of Sm is highly associated with global systolic function.[6,7]

Mitral annular descent has been further studied by others who used M-mode and 2-D echocardiography to demonstrate its predictive relation with LV function.[5]

There was no correlation between diastolic mitral annular velocities and systolic function in our study.

Gulati et al. reported that PVSm > 5.4 cm/s had a favorable sensitivity and specificity for rapidly identifying EF within the normal range. We, however, extend the prediction and suggest that VTI of Sm has a higher predictive power to estimate the overall EF and that VTI of more than 1.42 is associated with normal EF, irrespective of gender, diagnosis and loading conditions.

Significant correlation of tissue velocities has been seen with age and heart rate.[4] The peak S2 wave along the long axis varies with increasing age in healthy individuals. Our patients' mean age was about 45.6 years, so we avoided the effect of age on our study population.

Combining peak mitral annular velocities to other echocardiographic indexes of ventricular function such as Tei index may improve the accuracy of echocardiographic LV systolic assessment.

Study limitations

We measured the mitral annular velocities in patients with *nearly preserved* systolic function. We are currently working on another population of patients with more degrees of LV systolic dysfunction. This major goal requires a larger, time–consuming multi-institutional study enrolling a variety of other conditions such as various degrees of valvar regurgitations, etc.

Another limitation was using limited sampling of only two sites of mitral annular velocities in only one dimension. Nevertheless, some investigators believe that the lateral wall has the best power for reproducibility.

We, like others, omitted the S_m1 wave in our study to avoid its perplexing effects. Alternatively, it is more related to isovolumic contraction and may influence total Sm interpretation.

Conclusion

Our preliminary data indicated that, in carefully selected and limited patients, peak velocity and VTI of Sm in PW-TDI are reliable rapid indicators of preserved LV systolic function with linear correlation with EF measured by conventional echocardiographic methods. To predict EF by TDI, VTI of SM would be a better parameter. Further studies especially in those with more marked impairment in LVEF are required to better delineate this newly opened window in echo research.

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