Isovolumetric Relaxation Time "IVRT" as an Assessment of Left Ventricular Diastolic Function: M-Mode Derived Versus Doppler Derived

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Abstract:

Background: Isovolumetric Relaxation Time" IVRT" may be defined as: That part of the cardiac cycle between the time of aortic valve closure and mitral opening, during which the ventricular muscle decreases its tension without lengthening so that ventricular volume remains unaltered. During this period there is a drastic decrease in ventricular pressure without a change in ventricular volume but prior to mitral valve opening. IVRT can be estimated by M-Mode echocardiography with simultaneous phonocardiography or simply by determining the time interval between the maximal systolic excursion of the left ventricular posterior wall to the onset of mitral valve opening. More recently, Doppler technique has been used to assess not only IVRT but also MPI "Myocardial Performing Index"; comparisons of Doppler IVRT with catheterization measurement of this time period have shown reasonable correlations.

Objective: To compare M-Mode derived IVRT with Doppler derived IVRT.

Method: The study was performed on healthy individuals of age of 20-55y. Echo-Doppler Siemens V.Plus equipment with phased array 2.5MHz probe and PW or CW facilities was used. A good M-mode image of mitral valve excursion and left ventricular posterior wall systolic excursion was first obtained and the time between the mitral valve opening and the maximal systolic excursion of LV posterior wall was then calculated. Doppler IVRT was obtained by directing the Pulsed or continuous wave beam from apical 5 chamber view across the region between the aortic out flow tract and the mitral inflow tract. The spectral wave form obtained in this position should include aortic valve flow with valve closure and the onset of mitral inflow with E/A configuration. In this spectrum the aortic closure- mitral opening interval can be determined.

Results & conclusion: There was no significant difference between M-mode derived IVRT and Doppler derived IVRT. Since the later has been validated on the ground of correlation with catheterization, thus it seems feasible to use either techniques to assess LV diastolic function.

Introduction

Isovolumetric relaxation time represents the interval very early in diastole. It is defined as the time from aortic valve closure to mitral valve opening. Diastolic filling is preceded by isovolumic relaxation and occurs at low pressures (17). There is a drastic decrease in ventricular pressure without a change in ventricular volume but prior to mitral valve opening.

The IVRT has been used for more than 3 decades in clinical cardiology to determine left ventricular diastolic function (3). Normal values which have been obtained averages 76± 13ms; this refers to the ability of the ventricle to fill without abnormal increase in diastolic LV (and/or LA) pressure. It has been demonstrated that IVRT may be shortened in any condition causing a rise in left atrial pressure resulting in early mitral opening and may be prolonged in conditions causing diminished LV wall compliance. Impaired ventricular relaxation frequently causes delayed mitral valve opening with the prolongation of the IVRT (15). Further more, IVRT has been shown to increase in athletics (1).

There exist several methods to assess left ventricle diastolic function by echo. The assessment consists of a series of measurements based on Doppler technique at [1] the mitral inflow, [2] pulmonary vein flow, [3] tissue pulse Doppler measurement of mitral annulus, as well as ancillary 2D information and sometimes colour M mode of the mitral inflow (3).

M-Mode echocardiography with simultaneous phonocardiography traditionally has been used to assess the period between aortic closure and mitral opening. Much easier technique, IVRT can also be estimated by determining the time interval between the maximal systolic excursion of the left ventricular posterior wall to the onset of mitral valve opening (10).

Doppler technique has been used not only to assess IVRT but also MPI “Myocardial Performing Index” (3). In this technique, the Pulsed or continuous wave beam is directed from apical 5 chamber view across the region between the aortic out flow tract and the mitral inflow tract. The spectral wave form obtained in this position should include aortic valve flow with valve closure and the onset of mitral inflow with E/A configuration. In
this spectrum the aortic closure- mitral opening interval can be determined. Comparisons of Doppler IVRT with catheterization measurement of this time period have shown reasonable correlation (13).

Non Doppler indices have also been used to assess LV Diastolic dysfunction is a common underlying cause for left atrium enlargement (dilation) due to increased LV filling pressures, so **increased LA diameter** in 2D or M-mode is ancillary information regarding diastolic function assessment in absence of significant MV disease.

Although diastolic dysfunction has been defined clinically as heart failure in the presence of a normal ejection fraction, the echocardiographic assessment of diastolic function is important in confirming the diagnosis. Furthermore, the majority of patients with diastolic dysfunction is asymptomatic and can only be identified by echocardiography or other diagnostic tests. This was illustrated in a community-based survey from the Mayo Clinic, which evaluated 2042 subjects 45 years of age. Approximately 28 percent had some degree of diastolic dysfunction 7.3 percent moderate to severe, but only 1 percent were symptomatic (8). These findings would yield to the conclusion that abnormalities in LV diastolic function may precede or be independent of systolic dysfunction (7, 12).

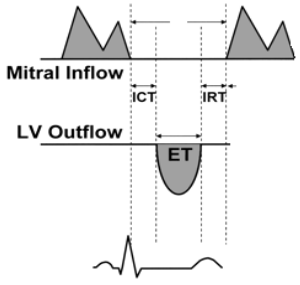
In our echo lab and perhaps in other labs, Doppler wave form configuration of transmitral flow was frequently adopted to assess LV diastolic function. However, There available evidence indicating that a slow relaxation pattern of mitral inflow may occur at age over 60 y (2); further, a restrictive pattern or merger of E / A waves may be encountered with increase of heart rate (3).

The goal of the present study is to determine the feasibility and accuracy of M- mode measured IVRT versus Doppler measured IVRT in assessment of LV diastolic function.

Methods

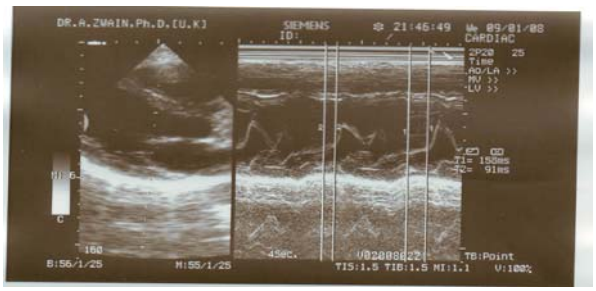
The study was performed on 50 healthy individuals of age ranging between 20- 55y. Echo-Doppler Siemens Versa Plus equipment with phased array 2.5MHz probe and PW or CW facilities was used. A good M-mode image of mitral valve excursion and left ventricular posterior wall systolic excursion was first obtained; the IVRT represents the time between the mitral valve opening and the maximal systolic excursion of LV posterior wall. Doppler IVRT was obtained by directing the Pulsed or continuous wave beam from apical 5 chamber view across the region between the aortic out flow tract and the mitral inflow tract. The spectral wave form obtained in this position should include aortic valve flow with valve closure and the onset of mitral inflow with E/A configuration. In this spectrum the aortic closure- mitral opening. Doppler IVRT represents the time calculated from the Aortic valve closure wave form to the commencement of the E wave of the mitral valve spectral wave form as shown in the schematic diagram (Fig1).

Fig 1: Schematic diagram showing measurements of Isovolumetric Relaxation Time (IVRT) and Isovolumetric Contraction Time (IVCT). (ET): Represents Ejection Time



The method of calculation adopted in M- Mode derived IVRT is shown in Fig 2

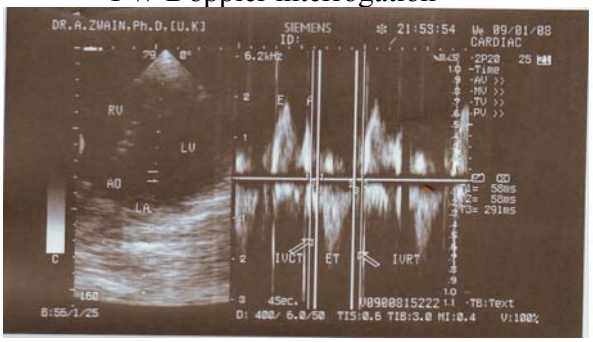
Fig. 2: M-Mode derived IVRT measurement



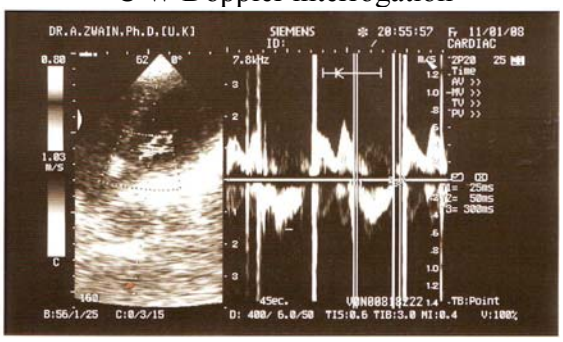
The method of calculation adopted in Doppler derived IVRT; using either PW Doppler or CW Doppler, is shown in Fig. 3

Fig 3: Doppler derived IVRT measurement

PW Doppler interrogation



C W Doppler interrogation



Average of measurements of IVRT of 2 cardiac cycles was performed. Data were statistically analysed using both paired samples T – Test and Linear regression test.

Results

The obtained M- Mode derived IVRT value was of a mean of 88.5 ± 3.17 msec range (50- 133) , and that of Doppler derived IVRT was of a mean of 83 ± 2.6 msec. range (58 - 133) . The difference was of a mean of 5.0 ± 2.86 msec. range (-0.763 - 10.76).

There was no significant statistical difference between M- Mode derived IVRT and Doppler derived IVRT: P > 0.05; R –Square 0.27 as shown in table 1 & 2 and in Fig 4

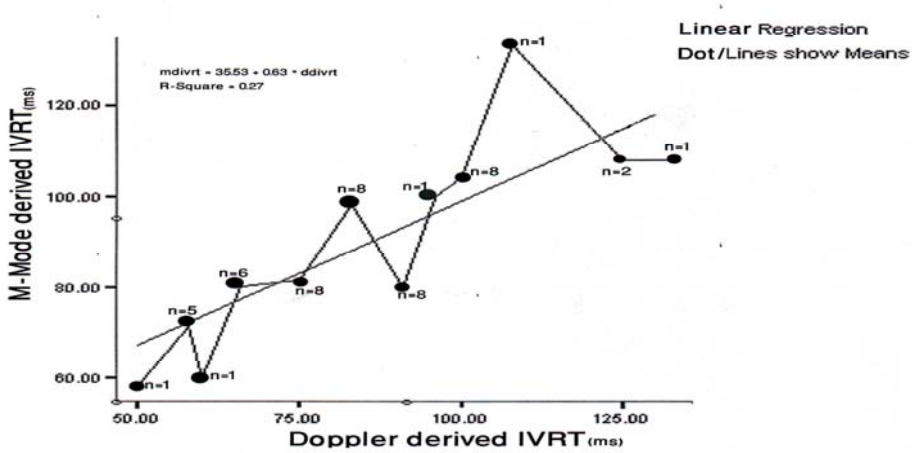
Table 1: Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	MDIVRT & DDIVRT	50	.521	.000

Table 2: Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	MDIVRT - DDIVRT	5.0000	20.2797	2.8680	-.7634	10.7634	1.743	49	.088

Fig 4: Correlation between M- Mode derived IVRT and Doppler derived IVRT



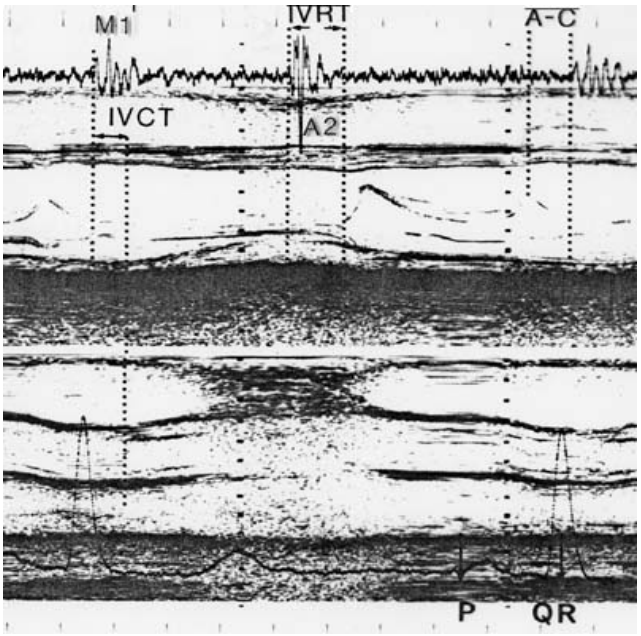
Discussion

Because myocardial relaxation and contraction are orchestrated by intracellular recycling of calcium ions, the timing of these cardiac events is in fact related to the health of myocardial cells (9). Furthermore, abnormalities of left ventricular (LV) diastolic properties may occur in the presence of normal ejection fraction or systolic fractional shortening, often yielding the conclusion that abnormalities in LV diastolic function may precede or be independent of systolic dysfunction. On these bases, emerges the benefit of the present study to screen patients for global cardiac function using easy and simple technique.

The traditional definition of diastole in ancient Greek language the term (διαστολε) means "expansion", includes the part of the cardiac cycle starting at the aortic valve closure - when LV pressure falls below aortic pressure - and finishing at the mitral valve closure. A normal LV diastolic function may be clinically defined as the capacity of the left ventricle to receive a LV filling volume able in its turn to guarantee an adequate stroke volume, operating at a low pressure regimen. In normal hearts the transition from contraction to relaxation begins much more before LV end-systole i.e., at 16% to 20% of the ejection period (5, 16) and even prior to aortic valve opening when LV contractility is severely impaired.

The present investigation provides a non-invasive approach of global diastolic cardiac function by the use of time intervals. In considering M Mode derived IVRT, the IVRT is expressed as the period between the peak of LV posterior wall excursion and the opening of the mitral valve. This resides in the fact that aortic valve closure has been shown to synchronize with peaked LV posterior wall excursion and the end of T wave in the ECG (11), as presented in Fig.5. This means the LV is completely repolarized which intern explains the validity of M- Mode periods in assessing LV diastolic function.

Fig 5: Isovolumetric Contraction & Relaxation time as synchronized with Phonocardiogram, M-Mode, Aortic root and ECG



Superimposed and synchronized M-mode tracings of the left ventricle with mitral valve (upper panel) and aortic root (lower panel). Phonocardiographic tracing at upper end and ECG tracing at lower end of figure. **A2**: First high frequency component of second heart sound on phonocardiogram.
A-C: Time interval between A (peak anterior movement of anterior leaflet during atrial contraction) and C (mitral valve closure) points of M-mode mitral valve tracing.
IVCT: Isovolumetric contraction time.
IVRT: Isovolumetric relaxation time.
M1: First high frequency component of first heart sound on phonocardiogram.
P: ECG P wave
QR: Q and R wave of the ECG

With regard to Doppler derived IVRT, in this investigation, both PW & CW spectral wave form measurements have been adopted and their average of two cardiac cycles was compared with the M- Mode measurement. As state earlier, comparisons of this time period with catheterization measurement have shown reasonable correlations (13). However, in the available literature reports, comparisons between M- Mode derived IVRT and Doppler derived IVRT are lacking.

The results of the present study demonstrate that there is no significant statistical difference between M- Mode derived IVRT and Doppler derived IVRT. In this sense, either techniques can be used to assess left ventricular diastolic function. The IVRT value of 88.5 ± 3.17 ms by M – Mode or 83 ± 2.6 ms by Doppler technique is rather consistent with previous studies (3, 10). with characteristics that lead to less than ideal image quality. Further limitation of this method is the presence of moderate to sever mitral or aaortic regurgitation which may affect Doppler spectra of left ventricular out tract” LVOT”. In such circumstances, one would resort to M-Mode technique as a substitute.

Limitations & clinical implications:

M- Mode derived IVRT technique is much easier and simpler than Doppler technique, however, in certain circumstances failure to obtain M-Mode measurements may be encountered: e.g. a correct and reasonable M- Mode tracing may be inaccessible as in conditions where cylindrical cardiac silhouette occurs, as. In case of C.O.A.D. or in case of difficulty in visualizing a clear cut posterior wall tracing in obese subjects. In such conditions Doppler technique may be used as a substitute.

Regarding Doppler derived IVRT, it is to be pointed out that this method gains dependant and requires significant operator experience to acquire reproducible data, especially in patients

Conclusion

The present study provides a reasonable and easy method to assess Left ventricular diastolic function, with considerable degree of versatility. Assessment of Left ventricular function on the ground of E/A ratio and wave form configuration, commonly adopted in echo labs, is invalid especially in subjects over 60 years as fore mentioned earlier

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