Correlation between Isovolumic Relaxation Time by Tissue Doppler Imaging and Pulmonary Artery Pressure

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Abstract

Background- The assessment of pulmonary artery pressure is important in clinical management and prognostic evaluation of patients with cardiovascular and pulmonary disease. Today, the accurate measurement of pulmonary artery pressure requires the use of cardiac catheterization. However, reliable non-invasive evaluation of pulmonary pressure still presents a problem. The purpose of the present study was to determine whether the isovolumic relaxation time (IVRT) obtained by pulsed Doppler tissue imaging from tricuspid annular motion could be used as an index of pulmonary pressure in patients with valvular, coronary and congenital heart disease.

Methods-Simultaneous tissue Doppler echocardiography and right heart catheterization were performed in 80 patients (mean age 46 years, 36 male) with valvular heart disease (n=59), coronary heart disease (n=20) and congenital heart disease (n=15). The patients were divided into three groups: group I: pulmonary systolic pressure (post-LV injection phase) in 25-40 mmHg range (n=28); group II: 41-60 mmHg range (n=37); and group III: 61-100 mmHg range (n=15). The isovolumic relaxation time (IVRT) was measured from the tricuspid annulus in apical 4C view at the junction of the right ventricular free wall and the anterior leaflet of the tricuspid valve by tissue Doppler imaging. Cardiac catheterization and pulmonary artery systolic-diastolic pressures (pre-LV injection and post-LV injection phase) were measured. The IVRT was compared with pulmonary artery systolic- diastolic pressures by means of linear regression analysis.

Results- There was a significant correlation in all the groups between the IVRT and the sum of pulmonary artery systolic-diastolic pressures in post-LV injection phase ($r= 0.99$, $P<0.0001$). The linear regression equation is:

***IVRT*= [(PA systolic pressure in post-LV injection phase) + (PA diastolic pressure in post-LV injection phase)] ± 5.**

Some factors such as RV function, underlying disease (valvular, coronary, congenital heart disease), age and sex have no effect on the calculated formula. The IVRT value was compared in the three groups: group I: 51.79 ms± 8.35 STD; group II: 74.19ms ± 10.51 STD; and group III: 108.27ms± 16.43 STD. The IVRT values between the three groups had significant differences ($P<0.0001$). An IVRT $\geq$ 77 ms predicted pulmonary artery systolic pressure (Post LV injection phase) $\geq$ 50 mmHg with a sensitivity of 93% and a specificity of 80%.

Conclusion- We conclude that the evaluation of the isovolumic relaxation time from the tricuspid annulus by Doppler tissue imaging provides a simple, rapid and non- invasive tool for estimating pulmonary pressure in patients with valvular, coronary and congenital heart disease***(Iranian Heart Journal 2005; 6 (3): 33-38).***

Key words: pulmonary artery pressure Ë tissue Doppler imaging Ë isovolumic relaxation time

Pulmonary artery pressure is an important hemodynamic variable used in the management of patients with cardiovascular and pulmonary disease.[1] However, most non-invasive evaluations of pulmonary hypertension have been an important clinical problem for many years. Pulmonary artery pressure is estimated

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invasively by the tricuspid regurgitation jet velocity, pulmonary acceleration time, right ventricular ejection time, pulmonary regurgitation and the isovolumic relaxation time in Doppler echocardiography.[2,3]
Thus, reliable non-invasive evaluation of pulmonary pressure still presents a problem.[1]
The aim of the present study was to investigate the relationship between the IVRT obtained by Doppler tissue imaging from tricuspid annulus motion and pulmonary artery pressure in patients with valvular, coronary and congenital heart disease.

Methods

Study population

Eighty patients admitted for diagnostic catheterization were examined by a pulsed Doppler tissue technique. Tissue Doppler examination was performed simultaneously with right-sided pressure recordings in all the patients.
The study population comprised 44 female and 36 male subjects, ranging in age from 18 to 73 years (average 44 years). Fifty-nine patients had aortic and mitral valve disease. Fifteen patients had congenital heart disease, and 20 patients had coronary artery disease. The patients were divided into three groups: group I: pulmonary artery systolic pressure (in post-LV injection phase) in the 25-40 mmHg range (n=28); group II: 41-60 mmHg range (n=37); and group III: 61-100 mmHg range (n=15).

Pulsed Doppler tissue imaging technique

Pulsed Doppler tissue echocardiography examinations were performed simultaneously with cardiac catheterization with the patients lying in a supine position. All the patients were in stable hemodynamic condition, and tracings were recorded during end- expiration. A commercially reliable ultrasound system (GE Vivid Seven) equipped with a multi-frequency phased array transducer of M3S and pulsed Doppler tissue imaging technique were used. [6,12]
The tricuspid annular systolic and diastolic velocities and the time intervals were acquired in apical four-chamber views at the junction of the right ventricle free wall and the anterior leaflet of the tricuspid valve by tissue Doppler imaging.[4]
The acoustic power, filter and gain were adjusted for detecting myocardial velocities. [7,10,11]
The peak systolic (Sa), peak early diastolic (Ea), peak late diastolic (Aa) annular velocities and the time between the end of Sa and the beginning of Ea were obtained by placing a sample volume with a fixed length of 0.52 cm at the junction of the RV free wall and the anterior leaflet of the tricuspid valve when imaged from the two-dimensional four-chamber view by using Doppler tissue imaging. [4,20]
All the recordings were made at a sweep speed of 50 and 100mm/s. Moreover, all the recordings were made with a simultaneous superimposed ECG. [13,14]
Values are presented as means of 3 consecutive beats.[6] (Figs. 1,2)

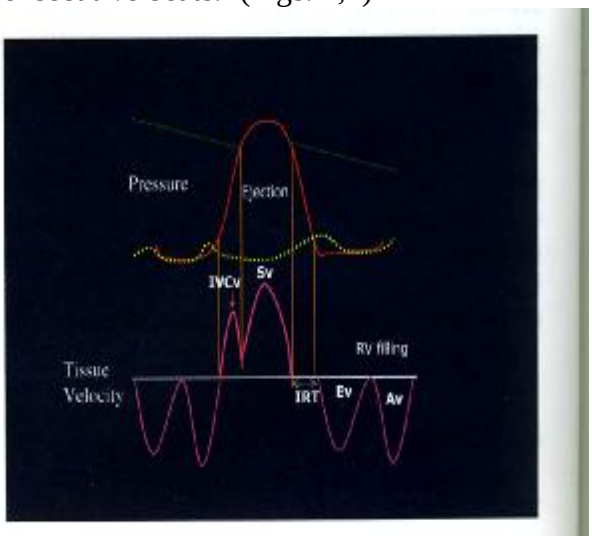

Fig. 1. Schematic traces form Doppler tissue imaging with super-imposed ventricular and atrial pressures.
IVC= isovolumic contraction velocity; Sv= systolic velocity during ejection period; Ev= early diastolic velocity; Av= atrial velocity; IRT= isovolumic relaxation time

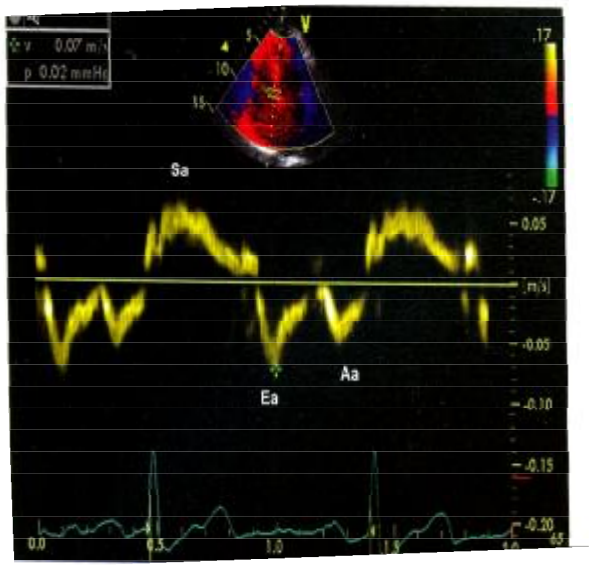

Fig. 2. Illustration of pulsed TDI of TV; Sa: peak systolic velocity at the anterior leaflet of TV; Ea: peak early diastolic velocity at the anterior leaflet of TV; IVRT, the time between the end of Sa and the beginning of Ea.

Cardiac catheterization

A 7 F, end-hole catheter) was used for hemodynamic measurements. Pulmonary artery systolic pressures in pre-LV injection, pulmonary artery diastolic pressure in pre-LV injection, pulmonary artery systolic pressure in post-LV injection and pulmonary artery diastolic pressure in post-LV injection phase were measured.

Statistical analysis

A commercially available statistical program (SPSS 10.1 and 11.1) was used.

Clinical, echocardiographic and right heart catheterization data are expressed as mean ± standard deviation.

Pearson's correlation and linear regression analysis were plotted to show certain relationships. A p-value less than 0.05 was considered significant.

Results

General characteristics of the study population

The patients' characteristics are presented in Table I.

Table I. Clinical and demographic characteristics of the patients

*Characteristics	Findings*
Gender (M/F)	36/44
Mean age (range) in yrs	44(18-73)
PA systolic pressure (Post-LV injection phase)	
25-40 mm Hg (n)	28
41-60 mmHg (n)	37
61-100 mmHg (n)	15
Mean (PASP plus PADP) in post-LV injection phase (mmHg)	71.97(37-135)
Mean IVRT (msec)	72.74 (38.130)
Referral diagnosis	
VHD (n)	59
CAD (n)	20
CHD (n)	15

PASP= pulmonary artery systolic pressure; PADP= pulmonary artery diastolic pressure; IVRT= Isovolumic relaxation time; VHD= Valvular heart disease; CAD= coronary artery disease; CHD= congenital heart disease.

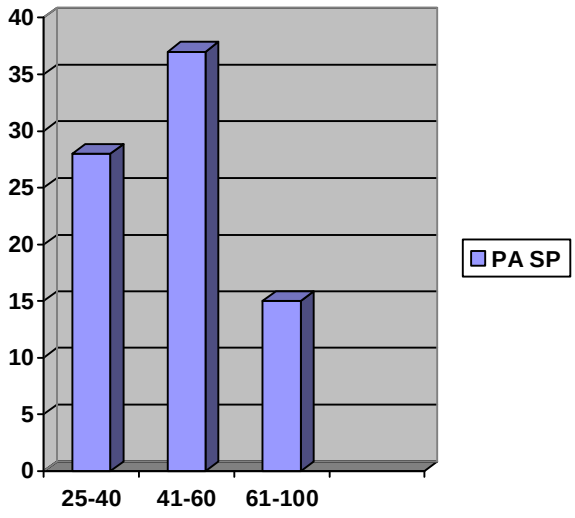

Fig 3. PA SP= Pulmonary artery systolic pressure after LV injection phase

Relationship between right ventricular isovolumic relaxation time and pulmonary artery pressure

A significant relationship was found between the IVRT and the sum of pulmonary artery systolic-diastolic pressure in post-LV injection phase (r= 0.99, P<0.0001, Fig.4). The linear regression equation is:

IVRT= [(PA systolic pressure in post- LV injection phase) + (PA diastolic pressure in post-LV injection phase)] ± 5.

The IVRT value was compared in the three groups: group I: 51.79 ms ± 8.35 STD; group II: 74.19 msec ± 10.51 STD; and group III: 108.27 msec ± 16.43 STD (Fig 5).

The IVRT values between the three groups had significant differences (P<0.0001). An IVRT > 77mscc predicted PA systolic pressure (Post-LV injection phase) ≥ 50 mm Hg with a sensitivity of 93% and a specificity of 80%.

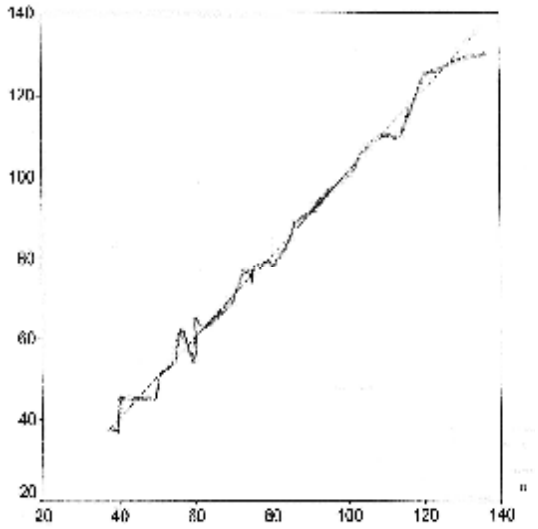

Fig 4. Correlation between isovolumic relaxation time and pulmonary artery systolic pressure plus pulmonary artery diastolic pressure in post-LV injection phase.

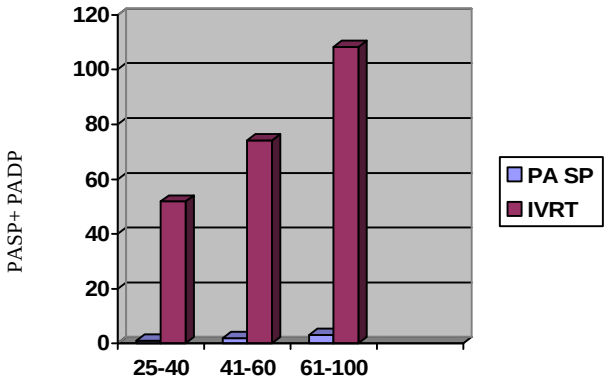

Fig 5. PA SP= Pulmonary artery systolic pressure after LV injection phase, IVRT= Isovolumic Relaxation Time

Reproducibility of the data

Intra-observer and inter-observer variability of the IVRT measurement was tested by repeated measurements in 10 consecutive tracings.

The IVRT correlated well between the intra- and inter-observer determinations, with a correlation coefficient of 0.99.

Discussion

We demonstrated that the isovolumic relaxation time of the right ventricular free wall, measured by pulsed Doppler tissue imaging could be used to estimate pulmonary pressure in the stress phase.

Previous investigators have described the use of various Doppler parameters to evaluate pulmonary pressure. These efforts have focused on the timing of such events as right ventricular pre-ejection time, ejection time and IVRT. The right ventricular isovolumic relaxation time is the interval between pulmonic valve closure and tricuspid valve opening. Previous studies indicate that this time increases with pulmonary hypertension.[3,16-19]

Diastolic RV dysfunction (lower tricuspid valve peak E, lower E/A and prolonged RV-IVRT) has been demonstrated in patients with pulmonary hypertension and in those with symptomatic congestive heart failure, even in the absence of pulmonary hypertension, suggesting a potential role for ventricular inter-dependence in impaired RV filling.[8,9]

In adults, pulmonic valve closure is difficult to ascertain, and the short time interval lends itself to measurement variability and error. [3,15]

Thus, we used TDI to precisely determine the time interval between the end of peak systolic velocity (Sa) and the beginning of early diastolic (Ea) in tricuspid annular velocities, along with simultaneous electrocardiography.

In a recent study, Lindqvist et al. showed that isovolumic contraction velocity could be useful in the detection of patients with elevated right ventricular filling pressure such as patients with pulmonary hypertension.[6] Bolca et al. showed that the IVRT was a reliable measurement of pulmonary artery pressure and vascular resistance with valvular and congenital heart disease by using Doppler tissue imaging. [5]

In the present study, we found that the IVRT was influenced by pulmonary pressure in post-LV injection phase. Some factors such as RV function, underlying disease (valvular, coronary and congenital heart disease), age and sex had no effect on it. The calculated formula may predict pulmonary artery pressure at rest and stress conditions.

Conclusion

Non-invasive determination of pulmonary pressure is possible using variables that are routinely obtained by Doppler tissue imaging.

We conclude that the evaluation of the isovolumic relaxation time from the tricuspid annulus by pulsed Doppler tissue imaging provides a simple, rapid and non-invasive tool for estimating pulmonary pressure in patients with valvular, coronary and congenital heart disease.

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