Evaluation of Right Ventricular Function before and after Dobutamine Stress Echocardiography in Healthy Individuals

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Abstract

Background- Several well-established echocardiographic parameters such as tricuspid annular plane systolic excursion (TAPSE), right ventricular outflow tract (RVOT) fractional shortening (FS), myocardial performance index, and Doppler tissue imaging have been used for the assessment of right ventricular (RV) performance. The aim of this study was to evaluate the response of various parameters of RV function to dobutamine infusion in healthy individuals.

Methods- Thirty-eight participants with negative dobutamine stress testing for the left ventricle and with a mean age of 57 years (range: 40-85 yrs) underwent echocardiography, including measurement of TAPSE, fractional shortening (FS), and TDI (S velocity, strain and strain rate of base, mid, and apex) of the right ventricle at rest and after dobutamine infusion according to standard dobutamine stress testing (DSE) for the evaluation of changes in RV function after DSE.

Results- There were significant increases in S velocity (61.1%, P<0.001), FS (19.7%, P<0.001), TAPSE (6.4%, PV=0.026), strain rate (SR) in base (201%), apex (114%) and mid-wall (71%, all P<0.001), and strain in the apical portion (21%, PV=0.001) after dobutamine. There was no significant difference in SR between the RV free wall segments, but strain at mid-segment was more than that in the apical and basal segments at rest.

Conclusion- All RV performance parameters increased with the infusion of dobutamine. The mean values for strain rate were homogenous in basal, mid, and apical segments at rest and significantly increased in all the segments. This was in marked contrast to mean strain values, which were greatest in the mid part of the RV free wall at rest and increased only in the apical segment after DSE ***(Iranian Heart Journal 2009; 10 (1):35-39).***

Key words: dobutamine ■ stress echocardiography ■ ventricular function

Right ventricular (RV) function is an important independent predictor of exercise capacity and mortality in patients with heart failure or pulmonary hypertension, independent of left ventricular function.[1,2] However, despite increasing interest in the echocardiographic estimation of RV function during routine assessment of cardiac function, estimation of RV reserve in healthy individuals during stress test has not been fully evaluated. It can be helpful in the assessment of pathologic RV response and detection of patients with decreased RV reserve in valvular or congenital heart disease.

Received Feb. 10 2007; Accepted for publication May 2, 2008.
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The aim of this study was to evaluate RV function by various parameters, especially TDI, before and after dobutamine stress testing in healthy individuals.

RV function can be quantified by various echocardiographic indices such as the RV index of myocardial performance, tricuspid annular plane systolic excursion (TAPSE), RV outflow tract (RVOT) fractional shortening (FS), and pulsed wave Doppler tissue imaging (DTI).[3-9]

There are several publications on DTI of the LV, whereas the application of DTI on the RV is limited especially after DSE.

Methods

Study population

In total, 38 individuals were included in our study from patients referred for an evaluation of ischemia to our center. They were eligible for inclusion in the study if they had visually and echocardiographically normal RV and LV systolic function at rest, negative DSE for ischemia in LV segments, and had no other disease that could be associated with RV dysfunction.

Resting echocardiography

Echocardiography was performed in the left lateral position. Two-dimensional (2D) and color Doppler myocardial imaging (CDMI) were performed (Vivid 7, GE, Horten, Norway, 3 MHz probe) and stored digitally for subsequent analysis. Study of TAPSE by M-mode and tricuspid annular velocity at the junction of the tricuspid annulus was done in the apical 4-chamber view by TDI and the RV lateral wall strain and strain rate by SI. RV out flow tract fractional shortening was measured in the parasternal short axis view.

For the assessment of regional longitudinal function, real time 2D CDMI-derived velocities were recorded from the RV free wall using apical 4-chamber views. High frame rate acquisition was used. Careful attention was taken to make the ultrasound beam parallel to the direction of wall motion. CDMI data were analyzed offline using specialized software (TVI, GE Vingmed Medical System) as previously described.[10,11]

Timing information was added using PW Doppler traces of the pulmonary and tricuspid valve for RV analysis.

From the velocity data, longitudinal SR and strain were estimated in the base, mid, and apical segments of the RV free wall.

Dobutamine stress echocardiography

Graded dobutamine infusion was administered through a peripheral arm vein in 3-minute stages at infusion rates of 5, 10, 20, 30, and 40 $\mu g \cdot kg^{-1} \cdot min^{-1}$. When necessary, atropine 0.25 mg was added during peak dobutamine infusion, maximally three times at 2-minute intervals, in an attempt to increase heart rate to a target of 85% of the age-predicted maximal level (220-age). Reasons for termination of infusion were achievement of target heart rate, maximal drug infusion level at a lower heart rate, development of ventricular tachycardia or ventricular fibrillation, and severe adverse effects and symptoms including angina pectoris. All of the parameters measured at rest were repeated at peak dobutamine infusion. All the analyses were performed by two observers (double checked), and the average of three measurements of each parameter was used for statistical analysis.

Statistical analysis

Values are presented as mean ± 1 SD. Comparison between the base and the mid and apical segments at rest and after DSE was performed using the repeated measure ANOVA model.

Percent changes in various parameters of RV function before and after DSE were measured via the paired *t*-test.

Evaluation of age and sex effects on RV function parameters was conducted by linear regression model and *t*-test, respectively.

A *P*- value <0.05 was considered statistically significant.

Results

Baseline data

The study group included 38 patients (with negative DSE for LV ischemia and normal hyperdynamic response). The mean age was 57 (range: 40 - 85 years), and 27 of the patients (71%) were female and 11 (28.9%) were male.

The mean value of TAPSE at baseline was 22.9±4mm, and there was a significant negative correlation between age and TAPSE (PV=0.01). The mean value of baseline tricuspid annular velocity was 12.9±2.9 cm/sec, and no significant correlation with age and sex was seen.

The mean value of fractional shortening was 62±12%, with no correlation with age (PV=0.17) but with correlation with sex, as it was higher in the females (PV=0.05).

The mean values of RV strain in the basal, mid, and apical portions were -17.7±7.9%; -27.5± 7.8%, and -22.9±10.1%, respectively. There was a significantly higher mean strain value in the mid segment of the RV free wall (PV<0.001).

The mean values of RV strain rate in the basal, mid, and apical portions were -1.43±0.68, -1.81±0.75, and -1.64±0.7, respectively, which were higher in the mid segment but there was no statistically significant difference and there was relatively homogenous strain rate in all the RV segments (PV=0.59). No correlation was seen between strain and strain rate with age and sex.

The baseline characteristics are listed in Table I.

Results after dobutamine stress test

The mean value of RV peak systolic tissue velocity at peak DSE was 19.7 ± 5 cm/s, which significantly increased (61.1%, PV<0.001) compared with resting S velocity.

The mean value of TAPSE was 23.8±3.7 mm with a statistically significant (6.4%, PV=0.026) increase compared to the resting value.

The mean value of FS was 72.8±11.9, with 19.7% increase with stress test (PV<0.001).

The mean values of RV strain in the base, mid, and apical segments were -20.6±10.3%, -27.6±6.9%, and -28±9.7 %, respectively, with 27.3%, 5%, and 21% increase compared with baseline RV strain, which was statistically significant only in the apical segment (PV=0.001) by the paired *t*-test, but a significant change in strain was seen overall by the repeated measure ANOVA model in all the myocardial segments after DSE (PV=0.019).

The mean values of RV strain rate in the base, mid, and apical segments were -3.5 ± 5.3, -3.2 ± 1.1, and -2.8±0.87 (l/s), respectively, with a significant (201%, 71%, and 114%, PV<0.001) increase compared with the resting values, and homogenous values in all the segments were seen.

Echocardiographic parameters after dobutamine stress testing and percent changes are listed in Table I.

Table I. Echocardiographic parameters before and after dobutamine stress testing

Variable	Mean±SD (baseline)	Mean±SD (after DSE)	Percent change (%)	P value
S velocity (cm/s)	12.9 ± 2.9	19.7 ± 5	61.1	<0.001
TAPSE (mm)	22.9 ± 4	23.8 ±3.7	6.4	0.026
RVOT Fractional shortening (%)	62 ± 12.8	72.8 ±11.9	19.7	<0.001
RV strain in base segment (%)	-17.7 ± 7.9	-20.6 ±10	27.3	0.136
RV strain in mid segment (%)	-27.5± 7.8	-27.6± 6.9	5.8	0.933
RV strain in apical segment (%)	-22.9 ± 10	-28 ±9.7	21.9	0.001
RV strain rate in base segment (l/s)	-1.43 ± 0.68	-3.5 ±5.3	201	0.019
RV strain rate in mid segment (l/s)	-1.81 ± 0.75	-3.2 ± 1.1	71	<0.001
RV strain rate in apical segment (1/s)	-1.64 ± 0.7	-2.8 ± 0.87	114	<0.001

Discussion

Sutherland et al. in a review article[11] showed that radial SR/strain values were difficult to measure from the normal thin (<6mm) RV free wall, as the small computational distance, combined with near field imaging artifacts and only longitudinal maximal systolic velocities/SR/strain can be reliably derived from the basal, mid, and apical segments of the RV free lateral wall. They showed[11] SR/strain profiles obtained were inhomogeneous. The mean values for SR/strain were lowest in the basal segments and increased toward the apex, that is, in contrast to regional peak velocities that decrease from base to apex.

In another study by Marwick et al.,[12] strain measurements of RV were higher than strain index measurements of LV and increased from base to apex. Weidmann et al.[13] found higher systolic strain and SR in the mid-wall segment of the RV. In our study, we showed that mean strain values were higher in the mid-wall segments and SR values were homogenous in all the RV segments. The fact that the RV sinus contributes most of the stroke volume[14] may explain the higher strain values in the RV sinus (mid-wall) segments; therefore, the measurement of RV strain in the mid-wall is better for evaluation in this part and lesser affected by annular movement compared to the RV basal parameters.

RVOT FS, TAPSE, and peak systolic velocity of the tricuspid annulus have been shown to be closely related to RV ejection fraction.[4,5,16] We have reported the mean value of TAPSE, S velocity, and RVOT FS in healthy individuals as 22.9mm, 12.9 cm/s, and 62%, respectively, which is in concordance with findings in earlier studies.[16,17]

Kjaergaurd et al. showed little or no variation with age and sex in the estimates of RV function in healthy individuals.[15] In our study, there was a reverse correlation between age and TAPSE and also fractional shortening correlated with sex; and there was no significant correlation between age, sex, and other parameters of RV function.

After dobutamine stress echocardiography (DSE), there were significant increases in RVOT FS (19%), S velocity of TV annulus (61%), and TAPSE (6%). The least change was seen in TAPSE, which may be due to the decreased longitudinal TV annulus movement toward the apex in higher heart rates and more circumferential shortening.

The mean values of strain rate increased significantly in a homogenous pattern at all the segments, but the strain values increased only in the apical segment. Nevertheless, with more analysis using the ANOVA model, an overall increase in all the myocardial segments strain was significant.

Strain and SR response to DSE was relatively similar to the left ventricular response to DSE. In normal myocardium, increasing doses of dobutamine are associated with increasing SR throughout the study, but in contrast, myocardial strain initially increases and then decreases as heart rate increases.[18]

Conclusion

This study showed significant increases in RV function parameters after dobutamine infusion, indicating significant RV reserve in normal right ventricular function. This may be helpful in the assessment of pathologic RV reserve in valvular and congenital heart disease.

Conflict of Interest

No conflicts of interest have been claimed by the authors.

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