ORAL SESSION
Role of stress echocardiography in assessing LV diastolic function

Friday, 8 December 2006, 11:00–12:30
Location: Novak

LV DIASTOLIC FUNCTION

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Can diastolic filling be reliably assessed during upright bicycle exercise? A test-retest reproducibility study
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There is growing interest in measuring diastolic parameters in response to exercise and to assess the physiological changes associated with exercise. However, echocardiography is usually performed immediately post exercise in a supine position, rather than during exercise per se. The aim of this study was to determine whether diastolic measurements are feasible and reproducible during upright bicycle exercise.

Methods: Twenty healthy subjects (9 men, average age 33.6 years) were studied on two separate days at rest (seated on a semi-recumbent bike) and during supine bicycle exercise at a constant 60 revolutions per minute. Load was adjusted to reach steady states at heart rates of 100 bpm and 120 bpm. Pulsed wave Doppler (PWD) of the mitral valve (MV) and tissue PWD at the medial MV annulus were obtained during each stage. Results were compared using t-tests, correlation coefficients, Bland and Altman plots and coefficient of variation (CV) calculated.

Results: The E/A ratio and E/Ea ratio at each stage and day are shown in the table. Excellent agreement was observed for each variable at rest and during exercise. Bland and Altman plots showed excellent agreement and no bias for E:A but poor correlation and agreement was seen for E:Ea during exercise.

Conclusions: Echo assessment of diastolic parameters is both feasible and reproducible during steady state exercise on an upright bicycle, although TDI measurements were less reproducible.

Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Upright Rest</th>
<th>HR=100 bpm</th>
<th>HR=120 bpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>E/A: Day1</td>
<td>1.67±0.1</td>
<td>1.32±0.06</td>
<td>1.21±0.06</td>
</tr>
<tr>
<td>E/A: Day2</td>
<td>1.72±0.1</td>
<td>1.28±0.07</td>
<td>1.17±0.06</td>
</tr>
<tr>
<td>E/A: diff</td>
<td>0.05±0.14</td>
<td>0.02±0.09</td>
<td>0.01±0.08</td>
</tr>
<tr>
<td>CV</td>
<td>4.24%</td>
<td>4.67%</td>
<td>4.8%</td>
</tr>
<tr>
<td>E/Ea: Day 1</td>
<td>5.52±0.24</td>
<td>5.95±0.29</td>
<td>7.08±0.43</td>
</tr>
<tr>
<td>E/Ea: Day 2</td>
<td>5.72±0.27</td>
<td>6.39±0.25</td>
<td>6.46±0.28</td>
</tr>
<tr>
<td>E/Ea: diff</td>
<td>0.06±0.39</td>
<td>0.39±0.38</td>
<td>0.45</td>
</tr>
<tr>
<td>CV</td>
<td>4.9%</td>
<td>4.5%</td>
<td>4.99%</td>
</tr>
</tbody>
</table>

HEART FAILURE

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Evolution of left ventricular diastolic parameters during exercise in heart failure patients
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Background: Exertional dyspnea is frequently due to exercise-induced increases in left ventricular (LV) filling pressure which might result from diastolic dysfunction or dynamic mitral regurgitation (MR). We sought to examine the correlates of exercise-induced changes in E/Ea in patients with systolic heart failure. E/Ea is increasingly used as reliable indicator of LV diastolic function.

Methods: For six consecutive patients underwent measurement of effective regurgitant orifice (ERO) of MR and of E/Ea (mean early diastolic mitral annular velocity at tissue Doppler imaging) at rest and during supine exercise test.

Results: E/Ea did not change significantly during exercise (20±4 at rest vs 23±12 at exercise, p=0.07). E/Ea at rest as well as at peak test correlated well with tricuspid pressure gradient (r=0.41 and r=0.58, p<0.01). At peak exercise, E/Ea increased in 27 (8.4±8.9) patients and decreased (-3.3±2.1) in the others. The increase in E/Ea during exercise was associated with a decrease in stroke volume (3.2±2.1 ml vs 15±15, p=0.0025), an increase in MR severity (changes in ERO 13±8 vs 5±9 mm2, p=0.0045), in tricuspid pressure gradient (25±12 vs 16±13 mm Hg, p=0.012) and in E/Ea peak (43±26 vs 26±22 cm/s, p=0.0006). Patients who stopped the test for dyspnea presented a larger rise in tricuspid pressure gradient, in MR severity and in E/Ea at peak test. With multivariate analysis, dynamic increase in MR severity at exercise remained the sole predictor of exertional dyspnea (p=0.01).

Conclusions: In patients with systolic heart failure, changes in E/Ea during exercise are highly variable from patient to patient and appeared to be related more to the dynamic component of MR rather than to reduced LV compliance.

LV DIASTOLIC FUNCTION

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Left ventricular relaxation and filling in upright bicycle exercise in patients with myocardial infarction
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Purpose: Myocardial infarction might cause diastolic dysfunction, and possibly increased left ventricular filling pressure (LVFP) at rest and during exercise. LVFP can be predicted by the ratio of early transmitral flow (E) to early diastolic annulus velocity (E'). Our aim was to look at mitral annulus velocities and E/E' ratio in upright bicycle exercise in patients with myocardial infarction compared to controls.

Methods: Eighteen patients (59±9 years, 4 women) with first-time myocardial infarction (MI) with no signs of heart failure, and 16 healthy controls (47±7 years, 6 women) were included. Colour-tissue Doppler images and transmitral flow were recorded at rest in supine and sitting position, and during upright bicycle exercise at 25, 50 and 75W (Vivid 7, GE Vingmed). Images were recorded two min after each change in workload. Systolic (S') and early (E') mitral annulus velocities were averaged from four points in the 4- and 2-chamber views.

Results: There was a trend for increased E/E' from supine to upright position at rest in both MI and C (9.6±3 to 12.4, p=0.07 and 8.0±2 to 9.7±2, p=0.09). This was mainly due to a significant reduction of E'. During exercise S' increased from 25 to 75W in both groups, while E' increased only in C (table). As E increased in both groups, E/E' increased significantly from 25 to 75W in MI, but not in C. Heart rate increased significantly from sitting rest to 75W in both groups (65±10 to 99±16 bpm in MI; 65±9 to 104±25 bpm in C). In MI, but not in C. Heart rate increased significantly from sitting rest to 75W in both groups (65±10 to 99±16 bpm in MI; 65±9 to 104±25 bpm in C). In MI, but not in C. Heart rate increased significantly from sitting rest to 75W in both groups (65±10 to 99±16 bpm in MI; 65±9 to 104±25 bpm in C).

Conclusions: The present study shows that patients with MI have limited relaxation reserve during exercise compared to controls. In contrast, systolic reserve was present in both groups. The increase in mitral flow during exercise was probably caused by increased filling pressure in patients, as opposed to increased left ventricular relaxation in controls.

Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sitting 25W</th>
<th>Sitting 75W</th>
<th>Sitting 25W</th>
<th>Sitting 75W</th>
</tr>
</thead>
<tbody>
<tr>
<td>E/E' Controls</td>
<td>9.7±2</td>
<td>7.7±1*</td>
<td>8.5±1</td>
<td>6.3±1*</td>
</tr>
<tr>
<td>E'/S' Controls</td>
<td>3.8±1*</td>
<td>6.0±2*</td>
<td>5.1±1</td>
<td>6.3±1*</td>
</tr>
</tbody>
</table>

*p<0.05 within group, sitting vs 25W, **p<0.05 within group, 25 vs 75W, †p<0.05 between groups
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Influence of dobutamine stress test on parameters of systolic and diastolic function in patients with hypertension
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The aim of the study was to investigate the influence of dobutamine stress test on parameters of left ventricular (LV) systolic and diastolic function as assessed by tissue doppler echocardiography (TDE) in patients with essential hypertension. The study included 75 patients - 50 women and 25 men (mean age 55.6±7.6 years) with arterial hypertension (mean duration 9.4±5.8 years), history of chest pain and normal coronary angiograms. Each patient underwent echocardiographic examination (HP Sonos 5500) to evaluate left ventricular mass index (LVMI). Left ventricular hypertrophy (LVH) was defined as LVMI >110 g/m² for women and >125 g/m² for men. In all patients dobutamine stress echocardiography was performed. Using pulsed wave (TDE) peak systolic (S), early diastolic (E') and late diastolic (A') velocities of basal segments of interventricular septum (IVS) and lateral wall (LW) were measured at rest and during high dose of dobutamine (40 ug/kg/min).

Results: During infusion of high dose of dobutamine we observed significant increase in all parameters of LV systolic and diastolic function measured with TDE, except from E' velocity for IVS (summarized in table below). Comparing the parameters of TDE between patients with LVH (n=36) and without LVH (n=39), we found that the only difference was IVS E' during high dose of dobutamine (significantl lower in patients with LVH -6.8±2.1 vs 8.0±1.23, p=0.047).

Conclusion: The stimulation of the LV with high dose of dobutamine did not influence the E' velocity of interventricular septum. This finding suggests that IVS is involved in the early process of left ventricular diastolic dysfunction in patients with arterial hypertension. The fact that patients with LVH had even lower values of E' during high dose of dobutamine comparing to those without LVH, adds further support to this hypothesis.

Table 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>At rest</th>
<th>sd</th>
<th>high dose of dobutamine</th>
<th>sd</th>
<th>N</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>IVS S?</td>
<td>6.93</td>
<td>1.47</td>
<td>11.53</td>
<td>3.05</td>
<td>75</td>
<td>0.0000</td>
</tr>
<tr>
<td>IVS E?</td>
<td>6.87</td>
<td>2.04</td>
<td>7.33</td>
<td>2.25</td>
<td>75</td>
<td>0.0925</td>
</tr>
<tr>
<td>IVS A?</td>
<td>9.04</td>
<td>1.84</td>
<td>12.26</td>
<td>2.69</td>
<td>75</td>
<td>0.0000</td>
</tr>
<tr>
<td>LW S?</td>
<td>7.88</td>
<td>1.94</td>
<td>12.55</td>
<td>3.57</td>
<td>75</td>
<td>0.0000</td>
</tr>
<tr>
<td>LW E?</td>
<td>9.41</td>
<td>2.93</td>
<td>10.44</td>
<td>3.51</td>
<td>75</td>
<td>0.0072</td>
</tr>
<tr>
<td>LW A?</td>
<td>9.66</td>
<td>2.45</td>
<td>12.32</td>
<td>3.06</td>
<td>75</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

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Left ventricular filling pressure as a determinant of exercise capacity in subjects with normal systolic function
J.-W. Ha 1; J.A. Ahn 1; J.M. Kim 1; S.W. Lee 1; S.J. Rim 1; Y.S. Jang 1; W.H. Shim 1; S.Y. Cho 1
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Background: Abnormalities of left ventricular (LV) diastolic filling are an important determinant of exercise intolerance in patients with LV systolic dysfunction. However, the relationship between Doppler echocardiographic LV filling parameters and exercise capacity has not been clearly defined in patients with normal systolic function. Diastolic mitral annular velocity (Ea) measured using Doppler tissue imaging (DTI) has been reported to be a preload independent index of myocardial relaxation and LV filling pressures can be estimated by combining mitral inflow (E) and Ea. The purpose of this study was to determine the relationship between surrogates of LV filling pressures (diastolic annular velocities combined with conventional Doppler indices and proBNP) and exercise capacity in patients with normal systolic function.

Methods and results: Three hundred fifty-nine patients (142 male, mean age 58±11) with normal systolic function underwent a symptom-limited graded supine bicycle exercise and two-dimensional and Doppler echocardiographic study at the same time. The mitral inflow velocities were traced and the following variables were derived: peak velocity of early (E) and late (A) filling and deceleration time (DT) of E velocity. Ea was measured at septal corner of mitral annulus by DTI from apical 4-chamber view. ProBNP was measured using a quantitative electrochemiluminescence immunoassay. Factors associated with a decreased exercise duration included an older age, female gender, higher E/Ea and proBNP, lower A and E/A, and prolonged DT; among them, E/Ea and proBNP was the strongest predictors of the exercise duration in the stepwise multiple regression analysis as well as age and gender (E/Ea, p=0.042; proBNP, p=0.0012).

Conclusions: In subjects with normal systolic function, E/Ea and proBNP, estimates of LV filling pressures, were strongly associated with the exercise capacity. This finding suggests that LV filling pressures may be an important contributing factor in determination of the exercise capacity in subjects with normal systolic function.

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Lack of end-diastolic volume recruitment during exercise in patients with diastolic heart failure
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1CNRS, Institute of Clinical Physiology, Pisa, Italy; 2University Federico II, Napoli, Italy; 3Clinica Cardiologica “Montevergine”, Mercogliano, Italy

Background: Systolic pressure/end-systolic volume ratio changes from rest to peak exercise (PVR, pressure volume relationship) can be assessed non invasively during stress echo.

Aim: To assess left ventricular contractility reserve and end-diastolic volume (EDV) changes during stress echo in patients with systolic or diastolic left ventricular dysfunction.

Methods: We enrolled 44 patients (34 males, age 56±16 years, resting ejection fraction=48±15%) referred for exercise stress echo. By selection, no patient developed regional wall motion abnormalities during stress. Three groups of patients were recruited: Group 1 (n=17), with systolic dysfunction (ejection fraction=30±6%) due to non-ischemic dilated cardiomyopathy (DCM); Group 2 (n=10) with diastolic heart failure (> 2 NYHA class, echocardiographic evidence of diastolic dysfunction, ejection fraction =53±5%); Group 3, normals, (ejection fraction =61±4%) undergoing routine screening. To build the PVR, the force was determined at different steps as the ratio of the systolic pressure (SP, cuff sphygmomanometer)/end-systolic volume (biplane Simpson rule).

Results: Group 1 patients with DCM had abnormal flat PVR (figure, left panel); patients with diastolic heart failure (DHF) had a normal up sloping PVR but abnormal end-diastolic volume decrease during stress (figure, right panel). Group 3 normal patients (NL) had up sloping PVR with non significant changes of diastolic volumes.

Conclusion: Decreased contractility in systolic dysfunction is associated with a flat PVR. Heart failure with preserved systolic function is characterized by normal contractile reserve (up sloping PVR) with a stress-induced abnormal decrease in the end-diastolic volume.