Stress Echo:

What is it? What can it do?

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Diastolic stress echocardiography (DSE) is an emerging non-invasive cardiac imaging technique used to differentiate the cause of exertional dyspnea in patients with unremarkable resting ECHOs.

Patients with preserved left ventricular ejection fraction (LVEF ≥ 50%) who present with dyspnea—particularly exertional dyspnea—may not have significant left ventricular (LV) diastolic dysfunction at rest. Yet, during exercise, increased heart rate, peripheral muscle and central organ oxygen demand may unmask significant LV diastolic dysfunction with exertion that is not detectable at rest. Doppler mitral inflow parameters, the early transmitral diastolic/tissue Doppler early diastolic velocity (E/Ea) ratio and Doppler-estimated pulmonary artery pressures, are valuable tools to help diagnose exertional diastolic heart failure (DHF) (Table 1). This article will discuss the protocols, advantages and pitfalls of DSE in patients presenting with exertional dyspnea.

Concepts

Grade I diastolic dysfunction—impaired relaxation with normal LV filling pressures—does not correlate with symptoms of DHF and generally confers a benign prognosis.[1] Therefore, elevated LV filling pressures, indicated by diastolic dysfunction grades of II or more, correspond with symptoms of dyspnea, DHF and worsening prognosis (Figure 1). In patients with underlying grade I diastolic dysfunction, increasing heart rate with exercise decreases diastolic filling time and LV compliance, which may result in elevation of LV filling pressures and exertional dyspnea.

Brenda's case

Brenda is a 64-year-old with hypertension and exertional dyspnea.

- BP: 147/89 mmHg,
- Heart rate: 87 bpm,
- BMI: 39 kg/m^2

Her electrocardiogram, chest x-ray and nuclear perfusion stress tests were normal and her baseline ECHO revealed normal left ventricular systolic function with grade I diastolic dysfunction (Figure 2).

Is Brenda's dyspnea due to obesity, or does she have another problem?

For the correct answer, see page 16.

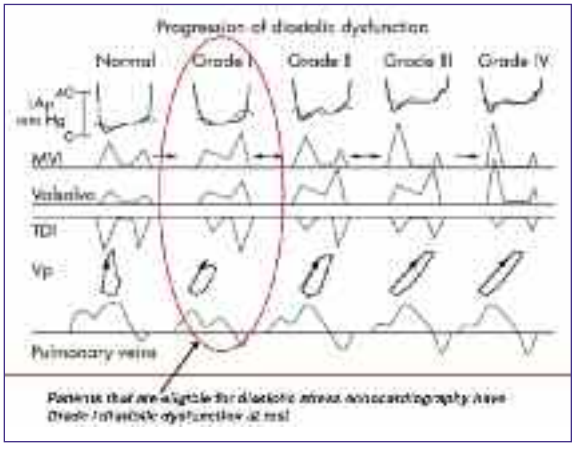

Figure 1. Progression of left ventricular diastolic dysfunction. Left atrial pressure (LAp), Doppler mitral valve inflow (MVI), Tissue Doppler imaging (TDI) and Mitral propagation velocity (Vp). Adapted from Reference 1.

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Table 1

Doppler parameters for left ventricular diastolic function

E: Early diastolic transmitral velocity

A: Late diastolic transmitral velocity after atrial contraction

E/A: Transmitral early diastolic/late diastolic velocity

DT: Mitral deceleration time

E/Ea: E/tissue Doppler early diastolic relaxation velocity

TR: Tricuspid regurgitation velocity for pulmonary artery pressure

Performing DSE

The patient with grade I diastolic dysfunction and normal LVEF undergoes baseline echocardiography to obtain LV systolic function, Doppler transmitral diastolic parameters, LV tissue Doppler imaging and estimation of pulmonary artery pressures using tricuspid regurgitation velocity (It should be noted that patients with grade II or greater diastolic dysfunction at rest already have findings consistent with DHF and do not need to undergo DSE). Next, with continuous ECG monitoring and interval BP recording, the patient exercises by treadmill or exercise bicycle to target heart rate (85% of maximum predicted for age). At target heart rate, echocardiography is performed, obtaining wall motion and the same Doppler diastolic parameters as at baseline. If available, supine exercise bicycle is ideal for DSE, as echocardiography can be comfortably performed during, rather than immediately after, target heart rate is reached.[2-5]

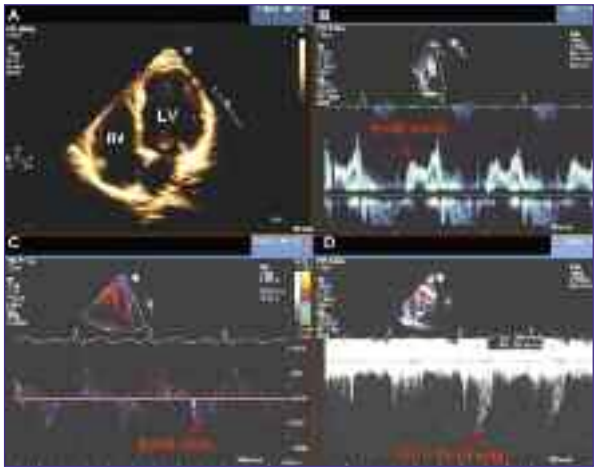

Figure 2. Resting ECHO. This patient is appropriate for DSE: she has normal left ventricular ejection fraction (LVEF = 60%) and E/A = 65/80 = 0.8, consistent with grade I diastolic dysfunction at rest. Normal LV filling pressure is confirmed by E/tissue doppler early diastolic relaxation velocity (E/Ea) = 65/8= 8. Pulmonary artery systolic pressure at rest is also normal, estimated at 30 mmHg: tricuspid regurgitation (TR) jet = 25 mmHg + 5 mmHg for right atrial pressure estimate.

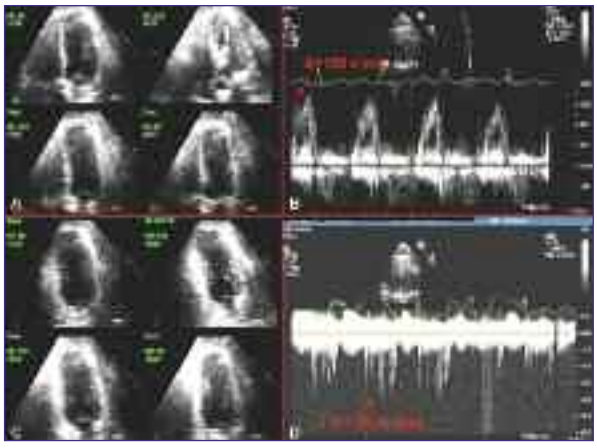

Figure 3. DSE. Panels A and C show normal wall motion during stress with hyperdynamic LVEF (> 70%). Panel B shows increases in peak E velocity to 120 cm/s (from a baseline E of 65 mmHg) and peak TR jet to 64 mmHg. Calculated E/Ea increases to 15 (using Ea velocity at rest = 8 cm/s).

More on Brenda's case

Brenda exercised for 11:14 on supine bicycle. With exercise:

- Heart rate increased to 132 bpm and BP to 201/104 mmHg
- Peak mitral inflow velocity (E) increased to 120 cm/s from baseline of 65 cm/s
- E/Ea ratio increased to 15 from baseline of 8
- TR jet increased to 4 m/s = 64 mmHg from a baseline of 25 mmHg (Figure 3)

Therefore, Brenda has findings consistent with exertional DHF. With BP control and weight loss, her dyspnea decreased significantly.

Frequently asked questions

What is the protocol for DSE?

- Perform comprehensive baseline ECHO with transmitral Doppler, LV tissue Doppler imaging and pulmonary artery pressure estimation using TR jet
- Attach ECG electrodes to patient's chest for continuous ECG monitoring
- Obtain baseline BP and heart rate
- Calculate target heart rate: 85% of (220 - patient's age)
- Start exercise (either supine bicycle or treadmill)
- Measure BP at three minute intervals
- At target heart rate, obtain echocardiographic images of the LV and repeat baseline Doppler parameters

Which findings indicate a positive DSE?

- An increase in the early diastolic mitral inflow velocity (E) with exercise to > 80 m/s
- An increase in the E/late diastolic velocity (E/A) ratio with exercise to > 1
- An increase in E/tissue Doppler early diastolic velocity (E/Ea) ratio to > 12
- An increase in pulmonary artery pressure to > 40 mmHg. This finding must accompany one of the three above, to distinguish from exercise-induced isolated pulmonary hypertension

Which patients are most at risk of exercise-induced DHF?

- Hypertensive patients
- Diabetics
- Patients with coronary or peripheral vascular disease
- Obese patients
- Elderly patients

What therapy is appropriate for patients with a positive DSE?

- Weight loss (if BMI > 30 kg/m^2)
- Strict BP control (< 130/85 mmHg at rest and during stress); ACE inhibitors or ARBs are preferred
- Use of β-blockers to blunt resting and exercise heart rate
- Judicious use of diuretic (*e.g.*, hydrochlorothiazide) to control volume status and BP

What are important conditions to exclude in patients being worked up for exercise-induced DHF?

- Comprehensive echocardiography with Doppler at rest must be performed to exclude LV systolic dysfunction (LVEF < 50%), prior MI, significant valve disease (such as aortic stenosis or mitral regurgitation) and isolated pulmonary artery hypertension
- Coronary ischemia can cause exertional dyspnea and must be excluded with stress testing prior to the DSE or during a comprehensive stress ECHO (to assess both cardiac ischemia and diastolic stress parameters in one test)
- Pulmonary diseases such as asthma/COPD and interstitial lung disease must be excluded by pulmonary function tests and chest x-ray as they can cause exertional dyspnea

Take-home message

- DSE is an important tool to help diagnose exercise-induced DHF in patients with otherwise unexplained exertional dyspnea
- Patients at risk of exercise-induced DHF are those with obesity, hypertension, coronary or peripheral vascular disease, diabetes and the elderly
- All that is needed is modern echocardiography equipment and a stress modality, such as a treadmill, or exercise bicycle with ECG and BP monitoring

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