STRESS ECHO AND ITS BIAS

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A stress test is a medical procedure designed to assess the health, efficiency, and overall function of the heart.

A stress test requires that a patient exercises on a treadmill or exercise bicycle while his or her heart rate, breathing, blood pressure, electrocardiogram (ECG), and feeling of well being are monitored.

Other non-exercise (pharmacological) stress tests are available and used for special cases where an exercise stress test is not appropriate.
Some Stress Testing Options

Stress ECG  Stress ECHO  Stress MPI/PET

EBCT/CTA  MRI

Stress echocardiography

Detection of myocardial ischemia induced by stress, by wall motion abnormalities seen by echocardiography.
Stress echocardiography has become an attractive tool in the hands of the clinical cardiologist helping in the diagnosis and risk stratification of patients with suspected or known coronary artery disease. However, there are some significant limitations to the technique, so that it remains difficult to acquire the data and to analyze the images.

Stress echocardiography

- Can be done after exercise testing (Sitting bicycle, Supine bicycle or Treadmill) or pharmacological stressors (Dobutamine, Arbutamine, Dipyridamole or Adenosine) infusion.
- Image acquired shortly after exercise and compared with baseline to detect newly induced wall motion abnormalities.
Stress echocardiography

- Overall accuracy - 85% sensitive if reached target HR, 90% specific.
- Compare to SPECT MPI, about 10% less sensitive and 10% more specific.
- Stress echo is not a full echo! Detail assessment of valvular function, pulmonary artery pressure...etc. are not routinely done.

Ischemic cascade

- Relaxation abnormalities
- Wall motion abnormality (19 sec)
- ST segment changes (30 sec)
- Chest pain (39 sec)
Goals of stress echocardiography

**DIAGNOSIS:**
- Detection of the presence and severity of CAD.
- Identification of patients at risk for a future cardiac event.

**PROGNOSIS:**
- Hospitalization for unstable angina, congestive heart failure
- Myocardial infarction

**GUIDE WORK-UP AND TREATMENT:**
- Who needs catheterization and revascularization?
- What medical therapies would be best?

Indications for dobutamine stress echo

- Indicated to increase sensitivity and specificity of stress testing.
- Evaluation of known or suspected coronary artery disease in patients unable to perform adequate exercise test.
- Risk stratification after myocardial infarction (viability detection).
- Risk stratification before non cardiac surgical procedure.
- Identification of viable myocardium in patients with left ventricular dysfunction.
- Before and after PCI / CABG.
Contraindications for dobutamine stress echo

- Ventricular arrhythmias.
- Recent myocardial infarction (one to three days).
- Unstable angina.
- Hemodynamically significant left ventricular outflow tract obstruction.
- Severe aortic stenosis.
- Aortic aneurysm or aortic dissection.
- Severe systemic hypertension.

Dobutamine protocol for echo

- Start at 5, 10, 15 mcg/kg/min if looking for viability but usually 10, 20, 30, 40 mcg/kg/min for 3 minutes infusions (begin imaging at 2 minutes)

- Use Atropine in .25 mg increments – start at 30 mcg/kg/min if HR is less than 100 b/m.
Stress echocardiography

In each stage of dobutamine compares pre & post:
- Regional contractility.
- Overall systolic function.
- Volumes.
- Pressure gradients.
- Filling pressures.
- Pulmonary pressures.
- Valvular function.

Response to Stress Echocardiography

- Normal response:
  - Increased left ventricular contractility
  - Hyperdynamic wall motion
- Ischemia:
  - New wall motion abnormality with stress
  - Decreased ejection fraction
  - Increase in end-systolic volume
- Scar from myocardial infarction:
  - Fixed wall motion abnormality with rest and stress
- Viability:
  - Biphasic response; improvement in wall motion with low dose dobutamine and worsening with high dose dobutamine.
16 segments model showing the relevant echocardiographic views with territories of coronary arteries (Armstrong, 2005).

Typical distributions of the right coronary artery (RCA), the left anterior descending (LAD), and the circumflex (CX) coronary arteries. The arterial distribution varies between patients. Some segments have variable coronary perfusion.
WALL MOTION SCORE

Give each segment a score.

1- Normal
2- Hypokinetic
3- Akinetic
4- Dyskinetic or aneurysmal

Add up all segment scores and divide by number of segment seen. 1 is normal.

******* WMSI 2.5 or greater has a poor prognosis.
Termination criteria

- **Positive finding by echo:** New wall motion abnormality
- ST depression > 3 mm
- BP limits:
  - => 220/120
  - <= 70/systolic if good ventricular function
  - any BP drop > 100 mmHg if poor or reduced LV function
- Arrhythmia: Non-sustained VT or sustained SVT
- Intolerable symptoms (Angina, nausea)
- Target Heart rate (> 85% of 220 - age)
- Maximum dose (40 µg/kg/min + up to 1 mg atropine)
Positive stress echo test

• Positive test:
  – ≥1 segment with new akinesia- or dyskinesia.
  – ≥ 3 segments with new hypokinesia.
  – ( = WMSI > 1.25 or increase by 0.25)

• Additional criteria:
  – Lack of hyperdynamic motion at peak stress (tardykinesia)
  – LV cavity dilation with stress
  – Decrease in global systolic function with stress
  – Development of diastolic abnormalities
  – New or worsening MR
  – Post-systolic thickening

Factors decreasing sensitivity of stress echocardiography

• Small vessels may not create large enough of an ischemic zone to generate a wall motion abnormality that is detectable.

• Suboptimal visualization of endocardium.
Main limitations for stress echo acquisition

Image quality during transthoracic scanning with insufficient visualization of left ventricle (LV) walls as in COPD, obesity, previous CABG ……etc

Influence of LV cavity size.

Probe positioning difficulties resulting in inadequate image planes.

The time-consuming serial acquisition of different image planes which has to be performed in a narrow time window during peak stress while wall motion abnormalities exist.

Main limitations for stress echo acquisition (cont..)

Regarding data analysis, subjectivity of image interpretation still is the major problem, which leads to poor inter-observer agreement and causes a relevant examiner-dependency.

All factors together result in a lack of ability to detect regional myocardial ischaemia and in reduced test accuracy.
Other limitations for stress echo

- Failure to achieve target heart rate
- Reliance on digital loop of single systole per view – 3 beats or tape backup on every case
- LBBB
- Under-calling inferior or lateral walls
- Overcalling inferior base: deformation from diaphragm
- Peculiarities of dobutamine response – hypotension due to low end systolic volume, milking at the apex

What About LBBB and Pacing Rhythm?
Left Bundle Branch Block and Stress Echo

- Abnormal septal motion is noted during stress echocardiography resulting in decreased accuracy in physician interpretation.

- Stress echocardiography has a poor positive predictive value to identify significant angiographic CAD in higher-risk patients with LBBB; however, the negative predictive value for hard ischemic events is similar to patients without LBBB. (William et al., 2007)

The LBBB does not disqualify a patient from a stress echo as you can read the anterior wall looking for an LAD lesion. The septal and anteroseptal walls are influenced by the LBBB so can not be used.
The advent of offline digital handling for data acquisition, storage and display, further improvements in echocardiographic imaging techniques and the development of a wide variety of stressor modalities contributed to rapid growth in the field of stress echocardiography.

Technical developments in echocardiography such as contrast echocardiography, myocardial Doppler imaging and 3D echocardiography may play an important complementary role.

New modalities with stress echo

- Tissue Doppler Imaging (TDI) [(PW-TDI) and color-coded (CC-TDI)].
- Strain and strain rate and post systolic thickening.
- Speckle tracking echocardiography.
- Real time 3D Stress Echocardiography.
- Stress contrast echocardiography.
Tissue Doppler Imaging

Tissue Doppler Imaging has been applied to stress echocardiography in order to overcome the limitations of visual analysis for myocardial ischemia.

TDI provides a quantitative analysis of regional myocardial function through the analysis of myocardial velocities.

Since velocity imaging is confounded by influence from velocities in other segments, the TDI – based modalities strain and strain rate imaging have been introduced to measure regional shortening fraction and shortening rate, respectively (deformation).

Tissue Doppler Imaging
pulsed wave TDI
Tissue Doppler Imaging
color-coded TDI

Strain and strain Rate

Strain rate imaging
- Helps improve objectivity.
- Removes tethering effect.
- In long term outcome studies, improved predictive value of stress echo.
- Not widely used.
- Can be measured off line.
- Increase the sensitivity of stress echo of about 10%.

(Hanekom et al., 2005)
Speckle-tracking echocardiography (STE) can be used to quantify wall strain in 3 dimensions and thus has the potential to improve the identification of hypokinetic but viable myocardium on dobutamine stress echocardiography (DSE).

However, if different myocardial layers respond heterogeneously, STE-DSE will have to be standardized according to strain dimension and the positioning of the region of interest.
Contrast stress echocardiography

Contrast echocardiography improves myocardial border detection and is useful for the assessment of myocardial perfusion. Opacification of LV cavity by injection of commercially available contrast agents improves visualization of the endocardium, leading to a more complete assessment of wall motion.
Contrast stress echocardiography (cont..)

This offers the potential to increase the sensitivity and specificity of the stress test.

Recent studies have confirmed the feasibility, accuracy and prognostic value of contrast stress echocardiography (Tsutsui et al., 2005).

However, the clinical implications of contrast stress echocardiography are limited due to the lack of a standardized technique.

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Realtime 3D stress echocardiography

Stress echocardiography with real time 3D echocardiography has some additional advantages such as a higher sensitivity in detecting small areas of wall motion abnormalities and a shortened time for image acquisition.

Three dimensional parametric contractility assessment during dobutamine stress echo at patients suspected of coronary artery disease sensitivity 90% Vs 85% for DSE, specificity 90% for both.

Further technical advances in realtime 3D stress echocardiography are expected to result in its ultimate widespread use in routine clinical practice.
Thank you