Stress Echocardiography in VHD: is myocardial contraction a reliable marker for ischemia?

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Milano 8 maggio 2012
Stress Echo and Cardiac death

Follow-up (months)

Cardiac mortality (%)

92% DET -
71.2% DET +

P = .0000

Sicari et al. JACC 2003
Stress Echo and Extent of Ischemia

Sicari et al. JACC 2003
Ischemia vs. Anatomy

![Graph showing bar chart with categories: Clinical Variables, Clinical Variables + Rest WMSI, Clinical Variables + rest WMSI + Stress Echo, Clinical Variables + rest WMSI + Stress Echo + Angio. The chart illustrates the comparison of global chi-square values for different sets of variables.](image)

Sicari et al. JACC 2003
Prognostic value of stress echocardiography

Subjects at risk

- SE (+) RWMA (+): 889, 362, 273, 206, 161, 122
- SE (+) RWMA (-): 719, 311, 229, 175, 123, 83
- SE (-) RWMA (+): 1468, 1011, 744, 583, 434, 320
- SE (-) RWMA (-): 3138, 2382, 1711, 1227, 884, 637

Follow-up (years):

- Hypertensives: 6,214
- Normotensives: 5,328

Cortigiani L and Sicari R Eur Heart J 2011
Current and Evolving Echocardiographic Techniques for the Quantitative Evaluation of Cardiac Mechanics: ASE/EAE Consensus Statement on Methodology and Indications Endorsed by the Japanese Society of Echocardiography

Victor Mor-Avi, PhD, FASE®, Roberto M. Lang, MD, FASE†, Luigi P. Badano, MD, FESC, Marek Belohlavek, MD, PhD, FESC, Nuno Miguel Cardim, MD, PhD, FESC, Genevieve Derumeaux, MD, PhD, FESC, Maurizio Galderisi, MD, FESC, Thomas Marwick, MBBS, PhD, Sherif F. Nagueh, MD, FASE, Partho P. Sengupta, MBBS, FASE, Rosa Sicari, MD, PhD, FESC, Otto A. Smiseth, MD, PhD, FESC, Beverly Smulevitz, BS, RDMS, Masaaki Takeuchi, MD, PhD, FASE, James D. Thomas, MD, FASE, Mani Vannan, MBBS, Jens-Uwe Voigt, MD, FESC, and Jose Luis Zamorano, MD, FESC†
Myocardial Ischemia

The direct observation of a developing systolic dysfunction combined with a post-systolic shortening indicates acute myocardial ischemia. However, the lack of clinical trials does not allow recommending specific parameters for differentiating various states of acute and chronic ischemia when baseline data are not available.
School of Athens in the stress echo lab

Contractility

Pressure – Volume loops:
Beautiful and impossible

Systolic thickening: quick and dirty

Regional wall function
Stress echo lab: contractility me too?

Peak systolic pressure =
cuff sphygmomanometer (r=.92)
Slutsky R et al. Peak systolic blood pressure/end-systolic
volume ratio: assessment at rest and during exercise Am J Cardiol, 1980 46: 813

Force = SP/ESVIndex
Suga H, Sagawa K, Shoukas AA.
Load independence of the instantaneous pressure-volume
ratio of the canine left ventricle and effects of epinephrine
## Contractility in stress echo lab: simplify for success

<table>
<thead>
<tr>
<th>Systolic Blood Pressure</th>
<th>+ 1/</th>
<th>End - systolic volume =</th>
<th>Contractility</th>
</tr>
</thead>
</table>

\[
\begin{align*}
\uparrow SP & \quad + \quad \downarrow ESV & = & \quad \uparrow \uparrow \text{Contractility} \\
\uparrow SP & \quad + \quad = ESV & = & \quad \uparrow \text{Contractility} \\
\downarrow SP & \quad + \quad \uparrow/\downarrow ESV & = & \quad \downarrow \text{Contractility}
\end{align*}
\]
Critical heart rate is the heart rate beyond which ESP/ESVI declines by 5%. Inagaki et al. Circulation 1999

Mulieri AL in “Heart Metabolism in Failure” RA Howart Ed. 1997
Subepicardial flow: beyond regional wall motion

- Lower LV volumes for any given pressure increase (Sabbah, Marzilli. Am J Physiol 1981)
- Possible anti-arrhythmic and anti-remodeling effect of subepicardium (Kaul S. Circulation 1995)
Inotropic reserve in the stress echo lab

<table>
<thead>
<tr>
<th></th>
<th>EXERCISE</th>
<th>DOBUTAMINE</th>
<th>PACEMAKER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contractility</strong></td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Inotropic reserve</strong></td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Bowditch treppe</strong></td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td><strong>User-friendly</strong></td>
<td>+</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td><strong>Requisites</strong></td>
<td>Capability to exercise</td>
<td>Intravenous line</td>
<td>Permanent pacemaker</td>
</tr>
</tbody>
</table>

JASE 2003 | EHJ 2005 | Eur J Heart Failure 2004
Force-Frequency Relationship (negative normal)

HF = 80 bmp
ESV = 30 ml
SBP = 140 mmHg
SBP/ESV = 4.6

HF = 115 bmp
ESV = 25 ml
SBP = 170 mmHg
SBP/ESV = 6.8

HF = 130 bmp
ESV = 23 ml
SBP = 190 mmHg
SBP/ESV = 8.2

HF = 140 bmp
ESV = 16 ml
SBP = 210 mmHg
SBP/ESV = 13

Delta SBP/ESV = 13 / 4.6 = 2.8
Force-Frequency Relationship (negative abnormal)

HF = 60 bmp
ESV = 120 ml
SBP = 110 mmHg
SBP/ESV = 0.9

HF = 80 bmp
ESV = 100 ml
SBP = 120 mmHg
SBP/ESV = 1.2

HF = 100 bmp
ESV = 81 ml
SBP = 130 mmHg
SBP/ESV = 1.6

HF = 120 bmp
ESV = 95 ml
SBP = 140 mmHg
SBP/ESV = 1.5

Delta SBP/ESV = 1.5 / 0.9 = 1.6
Contractility and Prognosis in Negative Stress Testing

Chronic Mitral Insufficiency: the role of LV function

Predictors of LV dysfunction

- Indexed End-Systolic Volume during exercise > 25 ml/m²
- Ejection Fraction <68%
- Increment of EF <4% during exercise

Leung DY et al JACC 1996
Exercise Echocardiography predicts LV dysfunction in asymptomatic AR

Medically treated

Valve Replacement

Marwick T et al. Heart 2000
Probability of Survival in Low Flow/Low Gradient Aortic Stenosis Patients Without CR on DSE

Tribouilloy et al. JACC 2009
Coronary flow reserve improves after aortic valve replacement for aortic stenosis

Hildick-Smith D et al. JACC 2000
Heart Valve Disease and CFR

**Pre-AVR**

REST

PEAK

CFR = 67 / 34 = 1.9

6 months post-AVR

REST

PEAK

CFR = 94 / 33 = 2.9
CANDIDATE DONORS

Study Protocol – the Last Generation 2006

PARAMETERS:
• HR (ECG)
• BP (cuff sphygmo)
• WMSI
• SP/ESV ratio

Donor excluded

CAD positivity (new wall motion abnormality of ≥1 segment)

Donor excluded

WMSI stress = 1
SP / ESV stress > than baseline

Eligible for donor
Negative stress: Wolf in Sheep clothes?

<table>
<thead>
<tr>
<th>RISK</th>
<th>Not-so-low</th>
<th>Very low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose/Load</td>
<td>Submaximal</td>
<td>Maximal</td>
</tr>
<tr>
<td>Diabetes</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Therapy</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Mitral Insufficiency</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Ultrasound Lung Comets</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Coro Flow Reserve</td>
<td>&lt;2</td>
<td>&gt;2</td>
</tr>
<tr>
<td>Force-Frequency Relationship</td>
<td>Flat-Biphasic</td>
<td>Steep</td>
</tr>
<tr>
<td>Death/year</td>
<td>&gt;3%</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

Cortigiani, JACC 2006
Sicari, Circulation 2004
Pierard, NEJM 2005
Agricola, JASE 2006
Rigo, AHJ 2006
Bombardini, EHJ 2005
**Negative stress echo and normal CFR: “A whiter shade of pale”**

<table>
<thead>
<tr>
<th>Time from test</th>
<th>Antianginal Therapy</th>
<th>Baseline Function</th>
<th>CFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;1 year</td>
<td>+</td>
<td>abnormal</td>
<td>abnormal</td>
</tr>
<tr>
<td>&lt;6 months</td>
<td>-</td>
<td>normal</td>
<td>normal</td>
</tr>
</tbody>
</table>

*Picano E and Sicari R. Eur J Echocard; 2004*