Contrast Stress Perfusion Echocardiography: Short Cases

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Disclosures

- Funding sources:
  - NIH/CTSA Grant Number UL1 RR024150
  - Mayo Foundation
  - ASPER Foundation
  - Definity: Lantheus Medical Imaging Inc.
  - Optison: GE Healthcare Inc.
  - Vasodilator stress drugs (Adenosine and Regadenoson), Astellas Pharma Inc.

- Off-label usage(s) of pharmaceuticals:
  - Definity
  - Optison
  - SonoVue
Outline

- Be Familiar with the Different Stress Myocardial Perfusion Protocols with *mini cases*
- Recognize the Incremental Benefits of Perfusion echo over Wall Motion Assessment

Ischemic Cascade

Supply-Demand Imbalance

Nesto et al. Am J Cardiol, 1987
**Contrast Echo PERFUSION**

- Contrast is routinely noted in the myocardium during low MI contrast imaging
- Echo Perfusion assess myocardial blood volume and velocity
- Off-label use of approved contrast agents for simultaneous assessment of myocardial perfusion and function
- Various Stress Protocols:
  - Dobutamine
  - Vasodilators
  - Exercise/supine Bicycle

  - Detection and risk stratification of CAD
  - Detection of myocardial viability
  - Assessment of CFR by MCE
  - Assessment of CFR by contrast-enhanced coronary Doppler imaging

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**Myocardial Perfusion Echocardiography**

simultaneously assess both myocardial function and perfusion

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Qualitative Analysis of MCE

1. Signal intensity (myocardial blood volume)
   - Brightness
   - Pattern (subendo/transmural)
   - Location (segments-territory)

2. Rate of filling (blood velocity)
   - Number of cardiac cycles
   - Mean microbubble velocity = 1 mm/sec
   - Ultrasound beam elevation = 5 mm
   - Rest: ~ 5 seconds (5–6 cycles)
   - Stress: ~ 2 seconds (2-3 cycles)

3. Defect vs. Artifact
   - False positive
     - Insufficient contrast
     - Shadowing or attenuation
     - Destruction of apical bubbles
     - Drop-out/inadequate image

Regadenoson Vasodilator Stress

Regadenoson 400 microgram bolus

Start Contrast

Pre Regadenoson

1 - 4 minutes

Stress Echo A4C, A3C, A 2C

Stop Contrast

Baseline A4C, A 2C, A3C

Abdelmoneim ss, Mulvagh SL et al., JASE 2015:28-1393
Regadenoson Vasodilator Stress Case 1

Rest 2-C

Stress 2-C

Normal WM
Abnormal Perfusion: LAD reversible

Regadenoson Vasodilator Stress Case 1

60% LAD
Regadenoson Vasodilator Stress Case 2

Rest 2-C

Stress 2-C

Abnormal WM
Abnormal Perfusion: RCA reversible

Regadenoson Vasodilator Stress Case 2

90% RCA
Regadenoson Vasodilator Stress Case 2

50% Cutoff
- WM: 80%
- MCE: 72%

70% Cutoff
- WM: 61%
- MCE: 66%

Sensitivity: 58% 50% Cutoff
Sensitivity: 61% 70% Cutoff
Specificity: 72% 50% Cutoff
Specificity: 66% 70% Cutoff

*p<0.05 compared to WM

Abdelmoneim SS, Mulvagh SL et al., JASE 2015:28-1393

Adenosine/Dipyramidole Vasodilator Stress Protocol

6 min
- Adenosine 140 μg/kg/min

3 min
- Rest Images

4 min
- Dipyridamole 56 mg/kg/min

2 min
- Stress Images

Porter et al., Cir Cardiovascular Imag, 2011
Adenosine Vasodilator Stress Case 1

Senior R et al, EHJ- CV Imaging, 2017:18,1205

Diagnostic Accuracy of stress MPE for detection of CAD during Vasodilators Stress

Senior R et al, EHJ- CV Imaging, 2017:18,1205
Dobutamine Stress Protocol

Senior R et al, EHJ- CV Imaging, 2017:18,1205

Dobutamine Stress Case 1

- 62 years male
- BMI =28kg/m²
- Known CAD
- Smoker, HTN
- Claudication
- Pre-op vascular surgery

Baseline ECG
**Dobutamine Stress Case 1 LVO**

- **Rest Apical 2 chamber Pre Flash**
- **Stress Apical 2 chamber Post Flash**

**Abnormal WM**

**Abnormal Perfusion:** RCA **reversible**

**Dobutamine Stress Case 1**

- Normal left circulation
- dRCA 50%
- PDA 40%
- pRCA 60% (at stent entry) / FFR 0.83 (normal)

- Medical treatment
- Surgery withheld in lieu of GDMT optimization
- Pt enrolled in cardiac rehab program
### Diagnostic Accuracy of stress Perfusion Echocardiography for detection of CAD During with Dobutamine or Exercise Stress

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>Stress method (dobutamine or exercise)</th>
<th>Patients undergoing coronary angiography</th>
<th>CAD present</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Author</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>Dobutamine or exercise</td>
<td>45</td>
<td>32</td>
<td>87</td>
<td>66</td>
<td>Cwai et al. 2000</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>Exercise (treadmill or bike)</td>
<td>44</td>
<td>28</td>
<td>75</td>
<td>100</td>
<td>Shimoni et al. 2001</td>
<td></td>
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<tr>
<td>44</td>
<td>Dobutamine</td>
<td>44</td>
<td>44</td>
<td>97</td>
<td>93</td>
<td>Olszewski et al. 2003</td>
<td></td>
</tr>
<tr>
<td>140</td>
<td>Dobutamine</td>
<td>132</td>
<td>85</td>
<td>81</td>
<td>77</td>
<td>Chiu et al. 2004</td>
<td></td>
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<tr>
<td>170</td>
<td>Dobutamine</td>
<td>170</td>
<td>127</td>
<td>91</td>
<td>51</td>
<td>Eberly et al. 2004</td>
<td></td>
</tr>
<tr>
<td>5350</td>
<td>Dobutamine</td>
<td>532</td>
<td>413</td>
<td>92</td>
<td>61</td>
<td>Agrell et al. 2008</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Exercise (bike)</td>
<td>42</td>
<td>25</td>
<td>88</td>
<td>88</td>
<td>Miszalko et al. 2007</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>Exercise (bike)</td>
<td>61</td>
<td>41</td>
<td>93 (quantitative)</td>
<td>80 (quantitative)</td>
<td>Miszalko et al. 2013</td>
<td></td>
</tr>
</tbody>
</table>

TOTAL (5832) = 1070 (total) + 795 Mean (95% CI) = 88 (84-91) **77 (69-85)**

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### Prognostic Role of stress Perfusion Echocardiography for detection of All cardiovascular event and Hard Event (death and non fatal MI)

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>Stress method (dobutamine or exercise)</th>
<th>Contract agent</th>
<th>Follow-up (months)</th>
<th>Total events (%)</th>
<th>Annual total event rate (%)</th>
<th>Annual total event rate (%) normal scan</th>
<th>Annual hard event rate (%)</th>
<th>Annual hard event rate (%) normal scan</th>
<th>Author</th>
<th>Year</th>
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<tbody>
<tr>
<td>107</td>
<td>Dobutamine</td>
<td>Sonoma</td>
<td>17 ± 7</td>
<td>35</td>
<td>12</td>
<td>7.75</td>
<td>16.94</td>
<td>3.62</td>
<td>3.64</td>
<td>2012</td>
</tr>
<tr>
<td>1024</td>
<td>Dobutamine</td>
<td>Definity</td>
<td>3.6 years (median)</td>
<td>54</td>
<td>20</td>
<td>1.03</td>
<td>2.82</td>
<td>1.24</td>
<td>3.31</td>
<td>2013</td>
</tr>
<tr>
<td>1533</td>
<td>Dipyr西洋紫</td>
<td>Sonoma</td>
<td>38 ± 9</td>
<td>38</td>
<td>38</td>
<td>2.54</td>
<td>11.76</td>
<td>2.63</td>
<td>11.76</td>
<td>2011</td>
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<tr>
<td>202</td>
<td>Dipyr西洋紫</td>
<td>Optima</td>
<td>32 ± 17</td>
<td>36</td>
<td>36</td>
<td>3.47</td>
<td>26.55</td>
<td>N/A</td>
<td>N/A</td>
<td>2011</td>
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<tr>
<td>450</td>
<td>Dipyr西洋紫</td>
<td>Sonoma</td>
<td>12 ± 3</td>
<td>13</td>
<td>8.66</td>
<td>11.28</td>
<td>0</td>
<td>6.15</td>
<td>2011</td>
<td></td>
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<td>113</td>
<td>Dobutamine</td>
<td>Definity</td>
<td>32 ± 28</td>
<td>42</td>
<td>42</td>
<td>1.53</td>
<td>14.91</td>
<td>1.53</td>
<td>14.91</td>
<td>2011</td>
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<tr>
<td>261</td>
<td>Dobutamine</td>
<td>Definity</td>
<td>14 ± 5</td>
<td>22</td>
<td>22</td>
<td>0.98</td>
<td>19.93</td>
<td>0.98</td>
<td>19.93</td>
<td>2009</td>
</tr>
<tr>
<td>88</td>
<td>Dobutamine</td>
<td>Definity</td>
<td>18 ± 9</td>
<td>24</td>
<td>24</td>
<td>1.67</td>
<td>19.19</td>
<td>N/A</td>
<td>N/A</td>
<td>2009</td>
</tr>
<tr>
<td>999</td>
<td>Dobutamine</td>
<td>Definity</td>
<td>21 ± 46</td>
<td>46</td>
<td>46</td>
<td>1.88</td>
<td>24.75</td>
<td>N/A</td>
<td>N/A</td>
<td>2009</td>
</tr>
<tr>
<td>145</td>
<td>Dobutamine</td>
<td>Definity</td>
<td>8 ± 3</td>
<td>34</td>
<td>34</td>
<td>10.17</td>
<td>50.58</td>
<td>N/A</td>
<td>N/A</td>
<td>2009</td>
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<tr>
<td>631</td>
<td>Dobutamine</td>
<td>Definity</td>
<td>16 ± 10</td>
<td>16</td>
<td>16</td>
<td>7.79</td>
<td>45.17</td>
<td>N/A</td>
<td>N/A</td>
<td>2009</td>
</tr>
<tr>
<td>121</td>
<td>Dobutamine</td>
<td>Definity</td>
<td>16 ± 10</td>
<td>16</td>
<td>16</td>
<td>7.79</td>
<td>45.17</td>
<td>N/A</td>
<td>N/A</td>
<td>2009</td>
</tr>
</tbody>
</table>

TOTAL (5479) = 380 (total) + 3.02% **p < 0.001**

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Tsutsui JM et al. Circulation 112:1444, 2005

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Senior R et al, EHJ- CV Imaging, 2017:18,1205
SUMMARY

1. CEE is **essential** to clinical echocardiography practice when Echo images are suboptimal
2. UCA are **safe**, have no radiation [0 mSv]
3. Contrast **Stress perfusion** Echo **complement** wall motion analysis—incremental information [yet remains off-label]
4. Microbubbles and ultrasound **interact**- operator skill—*Learning curve for image acquisition and interpretations*

Thank You!
Abnormal WM
Abnormal Perfusion": Multivessel CAD
  • LAD mixed
  • RCA reversible
  • Cx reversible (RWMA)

Dobutamine Stress Case 2 Perfusion
LM 50% , Mid LAD 90%, pRCA 100% (collateralized)
Dobutamine Stress Case 3  LVO
62 years old man, preoperative evaluation of SOB

Dobutamine Stress Case 3  Perfusion
Abnormal WM
Abnormal Perfusion : LAD reversible
**Dobutamine Stress Case 3 Perfusion**

LM 50%, Mid LAD 90%, pRCA 100% (collateralized)

Pre-PCI LAD

Post-PCI LAD

**Diagnostic Accuracy of stress MPE for detection of CAD**

(quantitative analysis on patient Level)

- 13 studies
- 527 patients
- Quantitative analysis in 574 (92%) patients