A View From the Other Side:
Role of MRI in Assessing Valvular Regurgitation

Echo Florida 2017

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Atlantic Health System
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Thomas Jefferson University

Q1

- How many randomized controlled trials have assessed the role of imaging in patients undergoing mitral valve surgery for MR?
  - 0
  - 1
  - 3
  - 5
  - 10
Q1

- How many randomized controlled trials have assessed the role of imaging in patients undergoing mitral valve surgery for MR?
  - 0
  - 1
  - 3
  - 5
  - 10

ASE GUIDELINES AND STANDARDS

Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation
A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Magnetic Resonance

William A. Zoghbi, MD, FASE (Chair), David Adams, RCS, RDMS, FASE, Robert O. Bonow, MD, Maurice Enriquez-Sarano, MD, Elise Foster, MD, FASE, Paul A. Grayburn, MD, FASE, Rebecca T. Hahn, MD, FASE, Yuchi Han, MD, MMSc,† Jody Heng, MD, FASE, Roberto M. Lang, MD, FASE, Stephen H. Little, MD, FASE, Degan J. Shah, MD, MMSc,† Steven Sheman, MD, FASE, Paola diagrammatically represents the guidelines and standards for noninvasive evaluation of native valvular regurgitation, developed in collaboration with the Society for Cardiovascular Magnetic Resonance.
- Why would you quantify regurgitant lesions with MRI?
- How do you quantify regurgitant lesions with MRI?

Is there a single reliable Echo parameter?

<table>
<thead>
<tr>
<th>Grading</th>
<th>MR severity</th>
<th>Echocardiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>None or mild aortic insufficiency</td>
<td>None or mild abnormalities</td>
</tr>
<tr>
<td>Moderate</td>
<td>Moderate aortic insufficiency or moderate leakages</td>
<td>Severe valvular lesions</td>
</tr>
<tr>
<td>Severe</td>
<td>Severe valvular lesions or severe leakages</td>
<td>Severe valvular lesions</td>
</tr>
</tbody>
</table>

- LV and LA sizes
- Qualitative Doppler
- Color flow jet area
- Flow convergence
- ECHO jet
- Semi-quantitative
- Pulmonary vein flow
- Mitral inflow
- Quantitative

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-wave</td>
<td>&gt;0.7</td>
<td>0.7-0.9</td>
<td>0.9-1.1</td>
<td>&lt;1.1</td>
</tr>
<tr>
<td>A-wave</td>
<td>&lt;0.5</td>
<td>0.5-0.8</td>
<td>0.8-1.0</td>
<td>&gt;1.0</td>
</tr>
<tr>
<td>E/A ratio</td>
<td>&gt;1</td>
<td>1-2</td>
<td>2-3</td>
<td>&gt;3</td>
</tr>
<tr>
<td>TAPSE</td>
<td>&gt;16</td>
<td>16-19</td>
<td>19-22</td>
<td>&lt;22</td>
</tr>
<tr>
<td>RVSP (mmHg)</td>
<td>&gt;40</td>
<td>40-50</td>
<td>50-60</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

Abbreviations: LA = left atrial, LV = left ventricular, TAPSE = tricuspid annulus plane systolic excursion, RVSP = right ventricular systolic pressure.
Qualifying MR: The Integrated Approach


<table>
<thead>
<tr>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>PISA</td>
<td>LV size</td>
<td>Jet area</td>
</tr>
<tr>
<td>Vena Contracta</td>
<td>EROA</td>
<td></td>
</tr>
<tr>
<td>LA size</td>
<td>RVol</td>
<td></td>
</tr>
</tbody>
</table>

Severe vs. Non-Severe MR: >80% inter-observer agreement

Biner S, JACC Img 2010;3:235-243

- Poor
- Fair
- Substantial

Percent (%)

- Doppler Jet: 25, 31, 44
- VC: 31, 25, 44
- EROA: 12, 50, 38
**ICC for Severe vs. Non-severe MR**

Biner S, JACC Img 2010;3:235-243

**CONCLUSIONS** The VC and PISA measurements for distinction of severe versus nonsevere MR are only modestly reliable and associated with suboptimal interobserver agreement. The presence of an identifiable effective regurgitant orifice improves reproducibility of VC and a central regurgitant jet predicts substantial agreement among multiple observers of PISA assessment. (J Am Coll Cardiol Img 2010;3:235–43) © 2010 by the American College of Cardiology Foundation

![Graph showing ICC values for Doppler jet area, VC, and PISA](image)

**EDITORIAL COMMENT**

Grading Severity of Mitral Regurgitation by Echocardiography: Science or Art?*

Paul A. Grayburn, MD, Paul Bhella, MD

*Dallas, Texas*

In closing, the ability to accurately distinguish nonsevere from severe MR is of critical importance for cardiologists as guidelines now recommend surgery for asymptomatic patients with severe MR. Biner et al. (3) demonstrated that even among experienced academic echocardiographers, intraobserver variability for common parameters used to grade MR severity is too high, implying that as a community, we struggle to accurately and reproducibly identify those who would benefit from surgery.
There is no accuracy without reproducibility (precision)

- Reproducible ✔
- Accurate ✔

- Reproducible ✔
- Accurate ✗

- Reproducible ✗
- Accurate ✗

- Reproducible ✗
- Accurate ❌

✗ Reproducible → Inaccurate

Advantages of MRI

- Whole chest imaging
- Choose the plane of imaging
- Natural contrast between blood and muscle
- Accurate measurements of flow
- System of “checks and balances”
How?

SSFP

Phase Contrast

L/R VEDV
L/R VESV
L/R VSV
L/R VEF

Ao flow
PA Flow

SSFP
Biventricular quantification

- Excellent muscle/blood contrast
- Whole chest imaging
- Geometric assumptions
Phase Contrast

Aortic Phase Contrast
No valve disease
No cardiac shunt

MR

LVSV
Ao flow
RVSV
PA flow

MR RVol. = LVSV – PA
= LVSV – Ao
= LVSV – RVSV

AR

LVSV
Ao flow
RVSV
PA flow

AR RVol. = LVSV – PA
= LVSV – RVSV
No valve disease
No cardiac shunt

MR + AR

Case
LV SV = 188 ml
RV SV = 129 ml
Qp = 133 ml
Qs = 97 ml

MR + ASD
Comparative Studies of Echo and MRI in Mitral Regurgitation

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Type</th>
<th>Yr</th>
<th>N</th>
<th>Absolute Agreement</th>
<th>Agreement if Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cawley et al</td>
<td>Retrospective</td>
<td>2013</td>
<td>26</td>
<td>13/23 (57%)</td>
<td>5/12 (42%)</td>
</tr>
<tr>
<td>Uretsky et al</td>
<td>Prospective</td>
<td>2015</td>
<td>103</td>
<td>27/103 (36%)</td>
<td>13/60 (22%)</td>
</tr>
<tr>
<td>Lopez-Mattei et al</td>
<td>Retrospective</td>
<td>2016</td>
<td>70</td>
<td>44/70 (63%)</td>
<td>2/10 (20%)</td>
</tr>
<tr>
<td>Sachdev et al</td>
<td>Prospective</td>
<td>2016</td>
<td>50</td>
<td>23/50 (46%)</td>
<td>10/15 (66%)</td>
</tr>
</tbody>
</table>
Gold Standard?

CMR and Echo: Is there a reference standard?
Q2

- What is the hemodynamic response of the left ventricle to MR?
  - No change in LV Volume
  - Increase in LV Volume
  - Decrease in LV Volume
**Left Ventricular Response to MR**

Gaasch W H, Meyer T E Circulation 2008;118:2298-2303

- Linear relationship between CMR Rvol. and degree of LV dilatation.
- Internal consistency MR quantified by CMR.

**Quantification of left ventricular remodeling in response to isolated aortic or mitral regurgitation**

Uretsky et al. JCMR 2010, 12:32

- Linear relationship between CMR Rvol. and degree of LV dilatation.
- Internal consistency MR quantified by CMR.
LV EDV ~ MR Severity

Uretsky et al. JCMR 2010, 12:32

✔ Linear relationship between CMR Rvol. and degree of LV dilatation.

✔ Internal consistency MR/CMR.

✔ MR quantification with CMR is reproducible and thus precise.

Intra-class correlation = 0.99, p < 0.0001

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EVEREST II: Negative LV Remodeling Post MV Surgery

Feldman T et al. NEJM;2011;364,1395-1406.
Discordance Between Echocardiography and MRI in the Assessment of Mitral Regurgitation Severity
A Prospective Multicenter Trial

Seth Uretsky, MD,* Linda Gillam, MD, MPH,* Roberto Lang, MD,† Farooq A. Chaudhry, MD,* Edgar Asgarian, MD, MPH,‡ Azhar Supairwala, MD,§ Srinivasa Guzrant, MD,§ Kavya Jain, MD,‖ Marjorie Subero, MD,‖ James J. Jang, MD,‖ Randy Cohen, MD,‖ Steven D. Wolff, MD, PhD*†‡§‖ (J Am Coll Cardiol 2015;65:1078-88)

1. Determine the frequency of concordance/discordance between Echo and CMR.

1. Which modality better predicts the degree of post surgical LV remodeling?

<table>
<thead>
<tr>
<th></th>
<th>Echo 1</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mild</td>
<td>Moderate</td>
<td>Severe</td>
</tr>
<tr>
<td>Echo 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Echo 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>9</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Moderate</td>
<td>5</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Severe</td>
<td>0</td>
<td>9</td>
<td>34</td>
</tr>
</tbody>
</table>

ICC = 0.65, p < 0.0001

Uretsky et al. JACC 2015;65:1078-88.
Echo: Severe vs. Non-Severe

<table>
<thead>
<tr>
<th></th>
<th>Non-Severe</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echo 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Echo 2</td>
<td>35</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>34</td>
</tr>
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Uretsky et al. JACC 2015;65:1078-88.

ICC for MR Qualification

Biner S, JACC Img 2010;3:235-243

Intra Class Correlation

<table>
<thead>
<tr>
<th>Doppler jet area</th>
<th>VC</th>
<th>PISA</th>
<th>Echo current</th>
<th>CMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.32</td>
<td>0.28</td>
<td>0.37</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ICC for MR Qualification

Biner S, JACC Img 2010;3:235-243

![Graph showing ICC values for different techniques]

CMR: Highly Reproducible for MR Severity

<table>
<thead>
<tr>
<th>CMR 1</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>41</td>
<td>6</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CMR 2</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>25</td>
<td>1</td>
</tr>
</tbody>
</table>

ICC = 0.90, p < 0.0001

Uretsky et al. JACC 2015;65:1078-88.
MRI: Severe vs. Non-Severe

<table>
<thead>
<tr>
<th>MRI 1</th>
<th>Non-Severe</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI 2</td>
<td>Non-Severe</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>0</td>
</tr>
</tbody>
</table>

Uretsky et al. JACC 2015;65:1078-88.

ICC for MR Qualification

Biner S, JACC Img 2010;3:235-243

<table>
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<th>PISA</th>
<th>Echo current</th>
<th>CMR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.32</td>
<td>0.28</td>
<td>0.37</td>
<td>0.58</td>
<td>0.9</td>
</tr>
</tbody>
</table>
### Echo-ASE vs. MRI

**MRI**

<table>
<thead>
<tr>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Echo**

<table>
<thead>
<tr>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Uretsky S et al, JACC 2015;65:1078-1088

### Echo-ASE vs. MRI

**MRI**

<table>
<thead>
<tr>
<th>Not Severe</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Echo**

<table>
<thead>
<tr>
<th>Not Severe</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>2</td>
</tr>
<tr>
<td>45</td>
<td>13</td>
</tr>
</tbody>
</table>

Severe MR 13/60 (22%)

Uretsky S et al, JACC 2015;65:1078-1088
**ECHO-PISA Rvol vs. MRI**

Uretsky S et al, JACC 2015;65:1078-1088

**Relationship between MRVol and LV Remodeling**

Uretsky S et al, JACC 2015;65:1078-1088
Asymptomatic MR: Mean f/u 2.5yrs for Indication for MVS

Myerson SG. et al. Circulation 2016

<table>
<thead>
<tr>
<th></th>
<th>N = 109</th>
<th>Conservative</th>
<th>Surgical</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI Rvol. (ml)</td>
<td></td>
<td>39 ± 20</td>
<td>66 ± 24</td>
</tr>
<tr>
<td>Echo Rvol. (ml)</td>
<td></td>
<td>74 ± 74</td>
<td>89 ± 36</td>
</tr>
<tr>
<td>EROA (cm²)</td>
<td></td>
<td>0.58 ± 0.8</td>
<td>0.57 ± 0.3</td>
</tr>
</tbody>
</table>

Survival Without Surgery by Echo and MRI

Myerson SG. et al. Circulation 2016
Conclusion

- Echocardiographic techniques for quantifying MR suffer from high interobserver variability, MRI does not.
- There is significant discordance between Echo and MRI when quantifying MR.
- This discordance is significant in patients referred for surgery.
- Based on emerging data Rvol quantified by MRI may be more accurate than 2D Echo techniques.

Future Directions

- Many questions remain regarding non-invasive imaging for MR.
- Larger studies.
- 3D echo techniques.
- Outcomes!!!