Mitral Regurgitation

MR is a common valve lesion
New ACC/AHA guidelines recommend valve repair in asymptomatic patients

Thus, we have a serious obligation to assess MR severity well
unnecessary surgery, particularly in the asymptomatic patient

Mitral Regurgitation Evaluation of MR Severity: 3D Echo or CMR?

Miguel A. Quinones, MD  MACC

Disclosures: none

Management of Mitral Regurgitation

First thing to do: Establish well the severity of regurgitation

1+ Never needs surgery
2+ Highly selective indications
   Ex: ischemic/functional MR
3+ and 4+ Surgery may be needed depending on symptoms, LV size/function and reparability

American Society of Echocardiography

Recommendations for Evaluation of The Severity of Native Valvular Regurgitation with Two-Dimensional and Doppler Echocardiography in Adult Patients

A report from the American Society of Echocardiography's Nomenclature and Standards Committee and The Task Force on Valvular Regurgitation


JASE 2003
Mitral Regurgitation
An Integrated Approach

- LV and LA size
- Valve appearance
- Transmitral E-velocity
- Spectral display density of jet on PW/CW
- Color flow Doppler imaging
  - Jet area
  - Vena contracta
  - Proximal flow acceleration
- Comparative flow of regurgitant vs. non-regurgitant valves

Assessment of MR Severity-An Integrated Approach- Supportive Signs

<table>
<thead>
<tr>
<th>Mild</th>
<th>Moderate (Intermediate)</th>
<th>Severe (3-4+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Should have all 3</td>
<td>Intermediate signs/findings</td>
<td>Should have all 3</td>
</tr>
</tbody>
</table>

- Normal LV size
- A-wave dominant mitral inflow with an E vel <1
- Soft density CW MR vel
- Enlarged LV and LA (when EF is normal)
- E-vel >1m/s with small A-vel
- Dense CW MR vel
- LVOT TVI <18cm

Assessment of MR Severity

Maximal Regurgitant Jet Area-Recommendations

*CENTRAL JETS ONLY*

<table>
<thead>
<tr>
<th>Reg. Jet Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
</tr>
<tr>
<td>Severe</td>
</tr>
<tr>
<td>Indeterminate</td>
</tr>
</tbody>
</table>

As long as the Max. Reg. Jet area is throughout systole and LV/LA size, E-vel and CW density support the estimated severity

Importance of Nyquist Limit

Nyquist = 21cm/s
Nyquist = 57cm/s
**PISA Method**

- **PISA**
  \[ PISA = 2\pi r^2 \]
- **Regurgitant Flow**
  \[ \text{Regurgitant Flow} = PISA \times Va \]
- **EROA**
  \[ \text{EROA} = \frac{\text{Regurgitant Flow}}{\text{peak MR Vel.}} \]
- **Regurgitant Volume**
  \[ \text{Regurgitant Volume} = \text{EROA} \times \text{TVI}_{MR} \]

**55F with Class III Dyspnea**

55F with Class III Dyspnea

- MR severity?
  - A. 1+
  - B. 2+
  - C. 3+
  - D. 4+

- PISA \( r = 0.5\text{cm} \)
- RegFlow = \( V_a \times 2\pi r^2 \)
  \[ = 23 \times 6.28 \times 0.25 \]
  \[ = 36\text{ml/s} \]

- EROA = Peak Reg flow / PeakVMR
  \[ = \frac{154}{570} = 0.27\text{cm}^2 \]

- Reg Vol = EROA \times \text{VTI}_{MR} = 0.27 \times 195 = 53\text{ml} 

63 male MD, asymptomatic with MR; Valve repair recommended based on echo findings using quantitative methods. He comes to MDHVC for second opinion.
63M asymptomatic with MR murmur

R = 1.1cm; V_a = 37cm/s; EROA = 0.62cm^2: Reg Vol = 94ml

63M asymptomatic with MR murmur

Wt = 152lbs; Ht = 69”; BSA = 1.84

Reg Vol = 94ml, systemic SV is 11ml. Is this possible?

63M asymptomatic with MR murmur

LVd = 4.7cm; LVEDV = 140ml; EF = 75%; SV = 105ml

Mitral Regurgitant Volume

Reg Vol = 104-69 = 35ml
Reg Frac = 35/104 = 34%
What is the MR severity?

What is the MR severity?

Effective Regurgitant Orifice Area

EROA = \frac{\text{regurgitant volume}}{\text{MR-TV}}

Assessment of MR Severity

Proximal Vena Contracta

Reg Volume

60ml

Reg Fraction

44%

LVOT SV = (2.3)^2 \times 0.785 \times 16.9 = 70ml

MA SV = (3.4)^2 \times 0.785 \times 15 = 136ml

2 mm

5 mm

8 mm
Quantitative Parameters Useful in Grading Mitral Regurgitation Severity

<table>
<thead>
<tr>
<th>Quantitative Parameter</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC width (cm)</td>
<td>&lt; 0.3</td>
<td>0.3-0.70</td>
<td>≥ 0.8</td>
</tr>
<tr>
<td>R Vol (mL/beat)</td>
<td>&lt;30</td>
<td>30-44</td>
<td>45-59</td>
</tr>
<tr>
<td>RF (%)</td>
<td>&lt;30</td>
<td>30-39</td>
<td>40-49</td>
</tr>
<tr>
<td>EROA (cm²)</td>
<td>&lt;0.20</td>
<td>0.20-0.29</td>
<td>0.30-0.39</td>
</tr>
</tbody>
</table>

Quantitative parameters can help sub-classify the moderate regurgitation group into mild-to-moderate and moderate-to-severe.

A 45 year old woman is referred for a second opinion regarding treatment of a valve condition.

- Hypertension for 20yra
- 5 year history of multiple sclerosis
- MR discovered recently
- She has fatigue and weakness and also complains of dyspnea with exertion described as a “need to take several deep breaths” during activities such as housework, walking or prolonged talking.
- She denies orthopnea or PND.
Parasternal Apical
VC = 6mm
PISA radius = 8mm

PW Doppler
CW Doppler
MR
TR = 2.7m/s
PASP = 29 + 5 = 34mmHg

LA vol=159ml
RA vol=41ml
LVd=5.1cm
EDV=149ml
EF=76%
SV=113ml

LVOd = 2.1cm; LVO-TVI = 20.9cm
LVO Vol. = 0.785 x (2.1)^2 x 20.9 = 72ml

Regurg. Vol = 111 – 72 = 39ml
Regurg Frac. = 39/111 = 35%

MAd = 2.6cm; MA-TVI = 21cm
MA Vol. = 0.785 x (2.6)^2 x 21 = 111ml

Mitral Annulus
LVOT
Parasternal Apical
VC = 7mm
PISA radius = 8mm

With these data you would:
1. Treat medically
2. Refer for valve repair
3. Refer for valve replacement
4. Do a TEE
5. Confirm findings with CMR

CMR Strengths
- High spatial resolution
- High temporal resolution
- Images can be taken at multiple sequential locations
- Image quality not affected by body habitus or lung disease
Accurate, reproducible and well validated for:

- LV and RV volumes
  - Ex vivo studies
  - In vivo
  - Equivalence of LV and RV stroke volumes in humans
  - Equivalence of LV stroke volume and aortic flow

Quantification of MR

- Phase Contrast MRI
  - LV stroke volume vs. aortic flow
  - LV stroke volume vs. pulmonary flow
  - Mitral flow vs. aortic flow

Reduction in sample size for clinical trials
Useful in serial clinical evaluations

<table>
<thead>
<tr>
<th>First Author (Year)</th>
<th>CMR Method</th>
<th>Reference Standard: Method</th>
<th>n</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sechtem (1988)</td>
<td>RF with biventricular volumes TTE: pulsed Doppler RF</td>
<td>8</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Nishimura (1989)</td>
<td>Regurgitant jet area and length by signal void TTE: jet area</td>
<td>20</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTE: jet length</td>
<td></td>
<td>0.74</td>
</tr>
<tr>
<td>Globar (1989)</td>
<td>RF with biventricular volumes catheterization: RF</td>
<td>13</td>
<td>0.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regurgitant jet area by signal void catheterization: angiographic grade by aortogram</td>
<td>20</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTE: jet area</td>
<td>26</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTE: jet area</td>
<td>20</td>
<td>0.74</td>
</tr>
<tr>
<td>Aurigemma (1990)</td>
<td>Regurgitant jet area by signal void catheterization: RF</td>
<td>26</td>
<td>0.67</td>
<td></td>
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<tr>
<td>Globits (1990)</td>
<td>RF with biventricular volumes catheterization: RF</td>
<td>26</td>
<td>0.67</td>
<td></td>
</tr>
<tr>
<td>Fujita (1994)</td>
<td>Velocity mapping: LV mitral inflow–Ao outflow RV and RF TTE: jet area</td>
<td>20</td>
<td>0.74 RF 0.87</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>RV index and RF</td>
<td></td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RF index and RF</td>
<td></td>
<td>0.96</td>
</tr>
<tr>
<td>Hundley (1995)</td>
<td>Velocity mapping: (LV cine and aortic phase contrast) catheterization: RV index</td>
<td>23</td>
<td>0.97</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>RV index and RF</td>
<td></td>
<td>0.96</td>
</tr>
<tr>
<td>Kizilbash (1998)</td>
<td>Velocity mapping: (LV cine and aortic phase contrast) RF</td>
<td>22</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>pulsed Doppler RF</td>
<td></td>
<td>0.82</td>
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### Reproducibility Studies

<table>
<thead>
<tr>
<th>First Author (Year)</th>
<th>CMR Method</th>
<th>n</th>
<th>CMR Reproducibility: Mean Difference±1 SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sechtem (1988)</td>
<td>RF with biventricular volumes</td>
<td>8</td>
<td>r=0.96, r=0.99</td>
</tr>
<tr>
<td>Nishimura (1989)</td>
<td>Regurgitant jet area and length by signal void</td>
<td>20</td>
<td>r=0.96</td>
</tr>
<tr>
<td>Globits (1990)</td>
<td>spin echo cine, RF with biventricular volumes</td>
<td>26</td>
<td>RVSV 7 mL, LVSV 7.3 mL</td>
</tr>
<tr>
<td>Fujita (1994)</td>
<td>velocity mapping: (LV mitral inflow-Ao outflow) RV and RF</td>
<td>29</td>
<td>RV r=0.99, RF r=0.98</td>
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<tr>
<td>Hundley (1995)</td>
<td>velocity mapping: (LV cine and aortic phase contrast) RV index and RF</td>
<td>23</td>
<td>FSV 51.3%, TSV 91.7%, RF 101.9%</td>
</tr>
<tr>
<td>Kon (2000)</td>
<td>velocity mapping: (LV cine and aortic phase contrast) RF</td>
<td>28</td>
<td>VM 0.6±4.8%, VM –2±7.7%</td>
</tr>
</tbody>
</table>

### CMR Findings

**CMR: MR Quantification**

$\text{Mitral Reg Vol} = \text{LV stroke volume} - \text{Aortic stroke volume}$

<table>
<thead>
<tr>
<th>Volumetric Analysis</th>
<th>LV</th>
<th>RV</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV End Diastolic</td>
<td>119</td>
<td>27</td>
</tr>
<tr>
<td>LV End Systolic</td>
<td>33</td>
<td>27</td>
</tr>
<tr>
<td>Cardiac Output (L/min)</td>
<td>5.2</td>
<td></td>
</tr>
<tr>
<td>Myocardial Mass (g)</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>Stroke Volume (mL)</td>
<td>85</td>
<td>89</td>
</tr>
<tr>
<td>Ejection Fraction (%)</td>
<td>56</td>
<td></td>
</tr>
</tbody>
</table>

**Mitral Reg Vol =** LV SV – Aortic SV = 86 – 55 = 31 ml  
Regurgitant Fraction (%) = $\frac{\text{Regurg vol}}{\text{MV Flow}} = \frac{33}{85} = 36\%$

**MODERATE MR**

<table>
<thead>
<tr>
<th>CMR: MR Quantification</th>
<th>Mitral Reg Vol = MA inflow – Aortic stroke volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>74 ml</td>
<td>55 ml</td>
</tr>
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**Mitral Reg Vol =** LV SV – Aortic SV = 74 – 55 = 19 ml
RESULTS:
LV Ejection Fraction: 73 %
Mitral Regurgitant Volume: 31 ml
Mitral Regurgitant Fraction: 36 %

CMR assessment of Mitral Regurgitation
– Accuracy and reproducibility
  • LV, LA volumes and EF
  • Regurgitant volume & RF
– Mechanism of Mitral Insufficiency

Additional Information provided
  Myocardial Viability
  Papillary Muscle Infarction
  Accurate LV Volumes / Dimensions
  LA Volume
  RV Function
What about TEE?

68M with progressive dyspnea and MR murmur

- The standard for assessment of MR severity when 2D is inadequate and CMR is not possible
  - However, severity criteria are qualitative rather than quantitative
  - Exception: Regurgitant area by 3D
- The gold standard for assessment of mechanism of MR
What about TEE?

MR Severity

- PISA
- Vena-Contracta
- Degree of swirling within LA
- Retrograde flow into PVs
- Jet area: least reliable

Vena Contracta Area by 3D

The Steps
1. Rotate data (if needed) to identify the jet long-axis
2. Define the short-axis VC zone (smallest region downstream)
3. Trace the VC Area

VC Area 0.65 cm²

Functional MR - Vena Contracta

3-D Echo in MR
Relationship between EROA & VC Diameter or VC Area

Little et al. J Am Coll Cardiol Img. 2008;1:695-704
Mitral Regurgitation

An Integrated Approach

- LV and LA size
- Valve appearance
- Transmitral E-velocity- usually >1m/s in severe MR
- Spectral display density of jet on PW/CW
- Color flow Doppler imaging
  - Jet area
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  - Proximal flow acceleration
- Comparative flow of regurgitant vs. non-regurgitant valves

*Use CMR and TEE as needed*