The New ASE Guidelines for Native Valvular Regurgitation

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(With caveats and comments from R. Hahn)

Disclosures
Rebecca T. Hahn, MD, FASE

• Core Lab Director for multiple tricuspid device trials for which I receive no direct compensation:
  – SCOUT Trial
  – Triluminate Trial
  – Tri-Repair Trial
• Speaker: Abbott Structural, GE, Philips, Boston Scientific
• Consultant: Gore&Associates, NaviGATE, Abbott Structural, GE, Philips
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

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New ASE Valvular Regurgitation Guidelines- Endorsed by SCMR

What is New?

• Emphasis on identification of Etiology/Mechanism of regurgitation
• 2D/3D TTE--an integrative approach & algorithms to assess severity
• When is TEE needed
• Important role of CMR & CMR methodology
• The challenge of co-existing valvular lesions
• A clinical perspective...
• Library of case studies on the web
Mitral Regurgitation
Indicators of Severity

- Mitral valve pathology
- LV/LA size
- Color Doppler:
  - Vena contracta, Jet Area, Flow convergence
- Mitral E; Pulmonary vein pattern
- Regurgitant flow/fraction
- CW density and contour

Carpentier Classification of Mechanisms of MV Regurgitation

<table>
<thead>
<tr>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Leaflet Motion</td>
<td>Excessive Leaflet Motion</td>
<td>Restricted Leaflet Motion</td>
</tr>
<tr>
<td>Annular Dilation</td>
<td>Perforation</td>
<td>Prolapse</td>
</tr>
<tr>
<td>Prolapse</td>
<td>Failure</td>
<td>a) Thickening/Fusion</td>
</tr>
<tr>
<td>Failure</td>
<td>b) LV/LA Dilation</td>
<td></td>
</tr>
</tbody>
</table>

Zoghbi W et al JASE March 2017
3D Echocardiography - MV

Normal  Fibroelastic Deficiency  Barlow’s Disease

Zoghbi W et al JASE March 2017

Grading of Mitral Regurgitation

Mitral Regurgitation - Color Doppler

3 Components of the Jet

Mitral Regurgitation

Mild Central  Severe Central  Severe Eccentric
Vena Contracta
Proximal Jet Width

VC width (cm)
- Mild < 0.3
- Moderate 0.3-0.7
- Severe > 0.7

3D Echocardiography in MR
Assessing VC Area

VC Area is often not circular in Secondary MR

Primary

Vena Contracta
EROA = 32 mm²

Secondary

Vena Contracta
EROA = 50 mm²
**Flow Convergence**

- Can be used semi-quantitatively
- Assumptions of hemispheric geometry
- Less accurate in eccentric jets
- Variability during the cardiac cycle and limitations in non-holosystolic MR

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**MR is not always Holosystolic**

*MR Duration Needs to be Accounted for*
Quantitation of MR


Measures EROA and calculates RegVol

Measures RegVol and calculates EROA
Flow Convergence (PISA)

Flow Convergence Method

Reg Flow = 2πr² x Va
EROA = Reg Flow / PKV_{Reg}
R Vol = EROA x VTI_{Reg}

Secondary Mitral Regurgitation

Assumptions of PISA
1. Flat Surface
2. Round Hole
3. No temporal variability
4. Hemispheric Flow Convergence
Secondary MR: Crescent-shaped Orifices

Functional MR is particularly difficult to quantify!

Dynamic Nature of FMR

Early and Late systolic peak in flow and orifice area

Hung J et al. JACC 1999;33(2);538-45

Dynamic PISA
A. FMR: early and Late peaks
B. FMR: early peak
C. Rheumatic: Late peak
D. Organic: late peak

PISA Assumes a hemispheric flow convergence

- Assumptions
  - The regurgitant orifice is a “pinhole”
  - Flow approaches a flat surface
  - The regurgitant orifice is circular
  - The isovelocity shells are hemispheres

- Other theoretical pitfalls:
  - Doppler echocardiography measures not speed but velocity which is dependent on the cosine of the angle between the probe and the direction of flow.

Pulsed Doppler Volumetric Quantitation

\[
SV_{LVOT} = CSA_{LVOT} \times VTI_{LVOT} = 0.785 \times d_{LVOT}^4 \times VTI_{LVOT}
\]

\[
SV_{MV} = CSA_{MV} \times VTI_{MV} = 0.785 \times d_{MV}^4 \times VTI_{MV}
\]
### Effective Orifice Regurgitant Area & Regurgitant Volume

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>EROA (cm²)</td>
<td>&lt; 0.2</td>
<td>0.20-0.29</td>
<td>0.30-0.39</td>
</tr>
<tr>
<td>RVol (mL/beat)</td>
<td>&lt; 30</td>
<td>30-44</td>
<td>45-59</td>
</tr>
<tr>
<td>RFraction</td>
<td>&lt;30</td>
<td>30-39</td>
<td>40-49</td>
</tr>
</tbody>
</table>

EROA cut-offs in 1st and 2nd MR are similar. RVol may be lower in 2nd MR.

### Mitral Regurgitation

**Indicators of Severity**

- Mitral valve pathology
- LV/ LA size
- Color Doppler:
  - Vena contracta, Jet Area, Flow convergence
- Mitral E; Pulmonary vein pattern
- Regurgitant flow/fraction
- CW density and contour

Anatomy

Color Flow

Pulsed Doppler

CW Doppler
Advantages
- Quantitative, valid in multiple jets and eccentric jets
- Provides both lesion severity and volume overload

Limitations
- Needs training; Cumbersome; wide (20%) confidence limits
- Measurement of flow at MV annulus is less reliable in calcific MV and/or annulus

Chronic Mitral Regurgitation by Doppler Echocardiography

Indeterminate MR
Consider further testing: TEE or CMR for quantitation

* Severe risk of underestimation of MR severity in eccentric, wall impinging jets; quantitation is advised
** All values for EROA by PISA assume holosystolic MR; single frame EROA by PISA, VCW, and VCA overestimate non-holosystolic MR
¶ Regurgitant volume for severe MR may be lower in low flow conditions.
Quantitation of MR with CMR

**Diastole**
- Ao
- LV: EDV = 250 mL

**Systole**
- LV: ESV = 100 mL
- MR

LV Stroke Volume (LSVV):
- LSVV = LVEDV - LVESV
- LSVV = 250 mL - 100 mL
- LSVV = 150 mL

Mitral Regurgitant Volume (M RVol):
- M RVol = LSVV - Ao Stroke Volume
- M RVol = 150 mL - 80 mL
- M RVol = 70 mL

Aortic Stroke Volume

Reg Volume = LV SV - Ao SV
### Aortic Regurgitation

<table>
<thead>
<tr>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Cusp Motion with Aortic Dilation or Cusp Perforation</td>
<td>Cusp Prolapse</td>
<td>Cusp Restriction</td>
</tr>
<tr>
<td>1. Sinus of Valsalva Annulus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Dilatation of the Sinuses of Valsalva and Sinusovitallar Junction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Dilatation of the Ventriculoarterial Junction (Annulus)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Aortic Regurgitation- Color Doppler**

![Color Doppler Image](image_url)

- **VC**: Venous Confluence
- **FC**: Aortic Valve
- **Jet Height**: Indicator of regurgitant volume
Integrative Approach to AR

• Integrative approach should be used
  • Supportive data
    • LV/LA size
    • PHT > 500
  • Specific Data (>90% Sp)
    • Reversal of flow in the aorta (EDVel > 20 cm/s)
    • Vena contracta > 0.6 cm
    • % LVOT ≥ 65%
  • Quantitative Data: 2D and 3D
    • Regurgitant Volume
    • Regurgitant Fraction
    • EROA

Attempt to understand discrepant measurements!

Aortic Regurgitation
Aortic compliance

- The aortic reverse/forward flow ratio (35±10%) was positively associated with parameters of aortic stiffness
Inconsistent AR severity scores can result from variations in ventricular and aortic stiffness.

- A more rapid decay in the diastolic transvalvular pressure gradient due to ventricular or aortic stiffening can lead to overestimation of AR severity by PHT.
Does AR meet specific criteria of mild or severe AR?

Intermediate Values: AR Probable moderate

Perform quantitative methods whenever possible to refine assessment

Specific Criteria for Mild AR
- VC width < 0.3 cm
- Central jet width < 25% of LVOT
- No or low flow convergence
- Soft or incomplete jet by CW
- PHT > 500 ms
- Normal LV size

Specific Criteria for Severe AR
- RVol ≥ 60 mL
- RF ≥ 50%
- EROA ≥ 0.3 cm²
- AR Grade IV

3 specific criteria for severe AR

Indeterminate AR
Consider further testing
TEE or CMR for quantitation

* Beware of limitations of color flow assessment in eccentric AR jets; volumetric quantitation and integration of other parameters is advised.
CMR in Aortic Regurgitation

Quantitation of AR with CMR
The Spectrum of Tricuspid Regurgitation

Mild TR  Severe Eccentric TR  Severe Central TR

PISA in Tricuspid Regurgitation

RV

TR Peak Velocity = 386 cm/s VTI of jet = 109 cm

Alias Velocity = 32 cm/s

Radius = 0.9 cm

EROA = 6.28 \times 0.9^2 \times 32 / 386 = 0.4 \text{ cm}^2

RVol = 0.4 \times 109 = 44 \text{ mL}
PISA LIMITED FOR FUNCTIONAL TR!

- Volume overload is well-tolerated for years
  - No reduction in RV function
  - Few symptoms of insidious onset
- Poor understanding about grading the severity of TR on Echo
  - Patients present LATE!!

3D vena contracta area = 1.5 cm²

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TR Grading: Work in Progress

SCOUT 1 is the first tricuspid valve device trial to use Doppler quantitative measures of disease severity

Hahn RT. Circ Cardiovasc Imaging. 2016 Dec;9(12)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Massive</th>
<th>Torrrential</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC (diam)</td>
<td>≤ 3 mm</td>
<td>3.1-6.9 mm</td>
<td>7-13 mm</td>
<td>14-20 mm</td>
<td>≥ 21 mm</td>
</tr>
<tr>
<td>EROA (PSA)</td>
<td>≤ 20 mm²</td>
<td>20-39 mm²</td>
<td>40-59 mm²</td>
<td>60-79 mm²</td>
<td>≥ 80 mm²</td>
</tr>
<tr>
<td>3D VCA or quant. EROA²</td>
<td>75-94 mm²</td>
<td>95-114 mm²</td>
<td>≥ 115 mm²</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RT Hahn and JL Zamorano. European Heart Journal - Cardiovascular Imaging (2017) 00, 1–2
doi:10.1093/ehjci/jex139
Specific Criteria for Mild TR
• Thin, small central color jet
• VC width < 0.3 cm
• PISA Radius < 0.4 cm at Nyquist 30-40 cm/s
• Incomplete or faint CW jet
• Systolic dominant Hepatic vein flow
• Tricuspid A-wave dominant inflow
• Normal RV/RRA

Specific Criteria for Severe TR
• Dilated annulus with no valve coaptation or flail leaflet
• Large central jet > 50% of RA
• VC width > 0.7 cm
• PISA radius > 0.9 cm at Nyquist 30-40 cm/s
• Dense, triangular CW jet or sine wave pattern
• Systolic reversal of hepatic vein flow
• Dilated RV with preserved function

Minority of criteria or Intermediate Values:
TR Probably Moderate

Yes, severe

No

Does TR meet most specific criteria for mild or severe TR?

Perform VC measurement, and May perform quantitative PISA method, whenever possible*

VC width < 0.3 cm
• * EROA < 0.2 cm²
• * RVol < 30 mL

VC width 0.3-0.69 cm
• * EROA 0.2 - 0.4 cm²
• * RVol = 30 - 44 mL

VC width ≥ 0.7 cm
• * EROA > 0.4 cm²
• * RVol ≥ 45 mL

Indeterminate TR
Consider further testing:
TEE or CMR for quantitation

* Clinical experience in quantitation of TR is much less than that with mitral and aortic regurgitation

CMR in TR and Right Heart Visualization & Quantitation

In my limited experience, CMR UNDERESTIMATES TR
Pulmonic Regurgitation

Specific Criteria for mild PR
- Small jet, with narrow width
- Soft or faint CW jet
- Slow deceleration time
- Normal RV Size

Specific Criteria for Severe PR
- Jet width/Annulus ≥ 70%
- Dense jet, PHT < 100 ms
- Early termination of PR flow
- Diastolic flow reversal in PA branches
- Dilated RV with NL function

Chronic Pulmonic Regurgitation by Color Doppler

Does PR meet most specific criteria for mild or severe PR?

Minority of criteria or Intermediate Values:
PR Probably Moderate

May Perform volumetric quantitative methods, if possible, whenever significant PR is suspected*

Yes, mild

RF <20%
Mild PR

RF 20-40%
Moderate PR

RF >40%
Severe PR

Yes, severe

Specific Criteria for Severe PR
- Jet width/Annulus ≥ 70%
- Dense jet, PHT < 100 ms
- Early termination of PR flow
- Diastolic flow reversal in PA branches
- Dilated RV with NL function

Indeterminate PR
Consider CMR for quantitation

Poor TTE quality or discordant parameters with clinical data, particularly when significant PR may be suspected

* Clinical experience in quantitation of PR is sparse.
CMR in Pulmonic Regurgitation
Quantitation of Rvol, RV Size & Function

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• When is TEE needed
• Important role of CMR & CMR methodology
• The challenge of co-existing valvular lesions
• A clinical perspective
• Library of case studies on the web: www.asecho.org/vrcases