EVALUATION OF CHRONIC MITRAL REGURGITATION:
ASSESSING MECHANISMS AND QUANTIFYING SEVERITY
2018 STRUCTURAL HEART DISEASE CONFERENCE
June 1, 2018

David A. Orsinelli, MD, FACC, FASE
Professor, Internal Medicine
The Ohio State University Division of Cardiovascular Medicine
Columbus, Ohio
DISCLOSURES

Institutional Research Support
Medtronic
Edwards
Abbott
EVALUATION OF CHRONIC MITRAL REGURGITATION

- One of the most common valve lesions
- Published guidelines for the clinical and imaging evaluation and management of these patients are available
  - This information has not penetrated into day to day practice in many locations
    - Many Barriers (Am Heart J 2016)
      - Lack of auscultatory skills
      - Echocardiographic quality / completeness
      - Lack of knowledge of primary vs secondary MR and the differences in treatment approach
      - Uncertainty as to appropriate timing of and treatment options available for treating MR
      - Lack of local expertise in MV repair
RESOURCES / GUIDELINES

Practice gaps in the care of mitral valve regurgitation: Insights from the American College of Cardiology mitral regurgitation gap analysis and advisory panel

Andrew Wang, MD, a Paul Grayburn, MD, b Jill A. Foster, MD, MPH, c Marti L. McCulloch, MBA, RCS d Vinay Badhwar, MD, e James S. Gammie, MD, f Salvatore P. Costa, MD, g Robert Michael Benitez, MD, h Michael J. Rinaldi, MD, i Vinod H. Thourani, MD, j and Randolph P. Martin, MD k Durham, NC; Houston, TX; Washington, DC; Pittsburgh, PA; Baltimore, MD; New Lebanon, OH; Charlotte, NC; and Atlanta, GA

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

EXPERT CONSENSUS DECISION PATHWAY

2017 ACC Expert Consensus Decision Pathway on the Management of Mitral Regurgitation

A Report of the American College of Cardiology Task Force on Expert Consensus Decision Pathways

PRACTICE GUIDELINE

2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease

A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines

Developed in Collaboration With the American Association for Thoracic Surgery, American Society of Echocardiography, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Anesthesiologists, and Society of Thoracic Surgeons

CLINICAL PRACTICE GUIDELINE: FOCUSED UPDATE

2017 AHA/ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease

A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines

THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER
Practice gaps in the care of mitral valve regurgitation: Insights from the American College of Cardiology mitral regurgitation gap analysis and advisory panel

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Am Heart J 2016;172:70-79

- Survey of PCPs, General Cardiologists / Imaging Cardiologists, Interventional Cardiologists and Cardiac Surgeons
- Identified significant knowledge gaps in the management of MR (e.g. indications for / timing of interventions, appropriate interventions, knowledge of surgeons’ expertise / volume, understanding echo reports)
- PCPs reviewed the images or discussed the Echo report with the interpreting physician < 30% of the time
  - What is on the report is taken as complete / factual
- Significant Gaps in the Quality / Completeness of Echo Performance Parameters and Reports
KNOWLEDGE GAPS IN THE ECHOCARDIOGRAPHIC ASSESSMENT OF MR: An Opportunity to Improve Patient Care

- What is missing from routine TTE Reports?
  - Reports reviewed by non-echocardiographers
    - < 2/3 of reports listed BP
    - Quantitative measures (VC, ERO, RV, RF) in < 50% of studies. 10% stated quantitative data was “never” reported
  - Interpreted / reported by Imagers
    - BP reported in 82%
    - VC (75%), ERO (64%), RV (45%), RF (39%)
- Imagers (vs non-imagers) who interpret Echo perform better

- What can / should be done
  - For PCPs / Non imagers
    - Review / ask questions of the interpreting physician
  - For Echocardiographers
    - Know when and how to quantitate MR (learn the techniques)
    - Define the anatomy and mechanism of MR
    - REPORT the findings
    - Be open to reviewing the findings with other providers
Practice Gaps in MR Assessment: Recommended Interventions
Am Heart J 2016

**Table VI. Advisory panel assessment of MR practice gaps and proposed interventions**

<table>
<thead>
<tr>
<th>Practice gap area</th>
<th>Specific gap</th>
<th>Advisory panel proposals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Echocardiography</strong></td>
<td>Recognition of primary vs secondary MR and the implications for treatment recommendations</td>
<td>Develop educational materials for cardiologists and cardiac focused on identification of pathoanatomic type of MR (primary or secondary) Target schools, accrediting bodies, and credentialing organizations to embed quantitative analysis and acquisition of MR into their respective programs. Improve MR quantitative protocols in ultrasound systems. Develop and teach a systematic approach to implement the integrated evaluation of MR severity to standardize quantitation. Webinars and/or on-site sessions teaching tools that illustrate the effective team approach to acquire, quantify and integrate comprehensively into the report. Work with IAC to add quantitative measure for any study with mild or greater MR. Standardize information necessary for all reports with mild or greater MR (BP, MV anatomy, MR mechanism, quantitative MR severity, prior study comparison) to be added to electronic report templates and for IAC. For patients with echo findings that are class 1 or 1A recommendations for mitral valve intervention, include guideline-based indications for intervention on echo report. Additional means of communication (eg, using electronic health record) to the ordering physician for patients with severe MR by echo. Team-based (echocardiographer, cardiac surgery, and/or interventional cardiology) review of echocardiograms of patients with planned mitral valve interventions to plan type of intervention and identify potential challenges or limitations. Regular reviews of sonographers ultrasound images and measurements in MR patients for quantitative measurements of MR severity and their interobserver variability. Regular reviews of echocardiographic reports to assess reporting of pathoanatomic type of MR, severity of MR with quantitative measurements, and guideline-based recommendations for intervention or follow-up. Develop online education and teaching tools for PGs and allied health professionals on the recognition of Class I criteria for MR therapy. Increased use of exercise testing to assess asymptomatic patients with severe MR. Randomized trials to assess timing of surgical intervention based on non-invasive testing (eg, exercise testing and BNP level in patients with a symptomatic MR). Integration of pathoanatomic type of MR in Society of Thoracic Surgeons database for mitral valve operations to more accurately understand repair vs replacement rates. Institutional reporting of mitral valve surgery volume and rate of mitral valve repair by type of MR to its physicians. Institutional long-term follow of MR repair surgeries to monitor survival and MR recurrence rates.</td>
</tr>
<tr>
<td>Sonographers</td>
<td>Incorporate quantification in education and implement in image acquisition</td>
<td></td>
</tr>
<tr>
<td>Cardiologists</td>
<td>Systematic approach to implement an integrative assessment of MR</td>
<td></td>
</tr>
<tr>
<td>Reporting</td>
<td>Standardize requirements for all reports when &gt; mild MR is present: BP, MV anatomy / mechanism of MR, quantitative measures, prior study comparison</td>
<td></td>
</tr>
<tr>
<td>CQI</td>
<td>Review image acquisition (sonographer) and interpretation / report (physicians). Correlation between TTE and TEE / intra-op findings</td>
<td></td>
</tr>
</tbody>
</table>
BRIDGING THE KNOWLEDGE GAP: IMPROVING THE ECHOCARDIOGRAPHIC ASSESSMENT OF MITRAL REGURGITATION
IDENTIFY / STAGE: History, Clinical Exam, TTE. Stages A-D

DEFINE: Mechanism / Classification

SEVERITY: Quantification (more than an “eyeball” assessment of color Doppler jet)

TREATMENT: Intervention only indicated for severe (or moderate to severe) MR. Options for clinical trials / best clinical (approved) therapies is determined by the mechanism of MR and confirmation of significant MR
OBJECTIVES

- Explain why it is important to **classify** the type of Mitral Regurgitation
  - Define the Echocardiographic Methods used to classify Mitral Regurgitation

- Explain the importance of **quantifying** the severity of Mitral Regurgitation
  - Review the Echocardiographic Methods used to assess the severity of Mitral Regurgitation
STAGES OF VALVULAR HEART DISEASE: MITRAL REGURGITATION

- Stage A: At risk (predisposition to develop VHD)
- Stage B: Progressive (mild to moderate disease, asymptomatic)
- Stage C: Asymptomatic Severe Disease (C1 without LV / RV dysfunction; C2 with LV / RV dysfunction)
- Stage D: Symptomatic Severe (symptoms due to VHD)
### Stages of Primary MR

(No changes from 2014 Guideline)

#### Table 15. Stages of Primary MR

<table>
<thead>
<tr>
<th>Grade</th>
<th>Definition</th>
<th>Valve Anatomy</th>
<th>Valve Hemodynamics</th>
<th>Hemodynamic Consequences</th>
<th>Symptoms</th>
</tr>
</thead>
</table>
| A     | At risk of MR | • Mid mitral valve prolapse with normal coaptation  
• Mild valve thickening and leaflet restriction | • No MR jet or small central jet area <20% LA on Doppler  
• Small vena contracta <0.3 cm | • None | • None |
| B     | Progressive MR | • Severe mitral valve prolapse with normal coaptation  
• Rheumatic valve changes with leaflet restriction and loss of central coaptation  
• Prior IE | • Central jet MR 20%-40% LA or late systolic eccentric jet MR  
• Vena contracta ≤0.7 cm  
• Regurgitant volume ≤60 mL  
• Regurgitant fraction ≤50%  
• ERO ≤0.40 cm²  
• Angiographic grade 1-2+ | • Mild LA enlargement  
• No LV enlargement  
• Normal pulmonary pressure | • None |
| C     | Asymptomatic severe MR | • Severe mitral valve prolapse with loss of coaptation or flail leaflet  
• Rheumatic valve changes with leaflet restriction and loss of central coaptation  
• Prior IE  
• Thickenning of leaflets with radiation heart disease | • Central jet MR >40% LA or holosystolic eccentric jet MR  
• Vena contracta ≥0.7 cm  
• Regurgitant volume ≥60 mL  
• Regurgitant fraction ≤50%  
• ERO ≥0.40 cm²  
• Angiographic grade 3-4+ | • Moderate or severe LA enlargement  
• LV enlargement  
• Pulmonary hypertension may be present at rest or with exercise  
• C1: LVEF >60% and LVESD <40 mm  
• C2: LVEF ≤60% and LVESD ≥40 mm | • None |
| D     | Symptomatic severe MR | • Severe mitral valve prolapse with loss of coaptation or flail leaflet  
• Rheumatic valve changes with leaflet restriction and loss of central coaptation  
• Prior IE  
• Thickening of leaflets with radiation heart disease | • Central jet MR >40% LA or holosystolic eccentric jet MR  
• Vena contracta ≥0.7 cm  
• Regurgitant volume ≥60 mL  
• Regurgitant fraction ≥50%  
• ERO ≥0.40 cm²  
• Angiographic grade 3-4+ | • Moderate or severe LA enlargement  
• LV enlargement  
• Pulmonary hypertension present | • Decreased exercise tolerance  
• Exertional dyspnea |
### Stages of Secondary MR
(Updated from 2014 Guideline)

JACC 2017;70:252

<table>
<thead>
<tr>
<th>Grade</th>
<th>Definition</th>
<th>Valve Anatomy</th>
<th>Valve Hemodynamics</th>
<th>Associated Cardiac Findings</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>At risk of MR</td>
<td>Normal valve leaflets, chords, and annulus in a patient with coronary disease or cardiomyopathy</td>
<td>No MR jet or small central jet area &lt;20% LA on Doppler</td>
<td>Normal or mildly dilated LV size with fixed (infarction) or inducible (ischemia) regional wall motion abnormalities</td>
<td>Symptoms due to coronary ischemia or HF may be present that respond to revascularization and appropriate medical therapy</td>
</tr>
<tr>
<td>B</td>
<td>Progressive MR</td>
<td>Regional wall motion abnormalities with mild tethering of mitral leaflet</td>
<td>ERO &lt;0.40 cm²</td>
<td>Regional wall motion abnormalities with reduced LV systolic function</td>
<td>Symptoms due to coronary ischemia or HF may be present that respond to revascularization and appropriate medical therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annular dilation with mild loss of central coaptation of the mitral leaflets</td>
<td>Regurgitant volume &lt;60 mL</td>
<td>LV dilation and systolic dysfunction due to primary myocardial disease</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Asymptomatic severe MR</td>
<td>Regional wall motion abnormalities and/or LV dilation with severe tethering of mitral leaflet</td>
<td>ERO ≥0.40 cm²</td>
<td>Regional wall motion abnormalities with reduced LV systolic function</td>
<td>Symptoms due to coronary ischemia or HF may be present that respond to revascularization and appropriate medical therapy</td>
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<td>Annular dilation with severe loss of central coaptation of the mitral leaflets</td>
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<tr>
<td>D</td>
<td>Symptomatic severe MR</td>
<td>Regional wall motion abnormalities and/or LV dilation with severe tethering of mitral leaflet</td>
<td>ERO ≥0.40 cm²</td>
<td>Regional wall motion abnormalities with reduced LV systolic function</td>
<td>HF symptoms due to MR persist even after revascularization and optimization of medical therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annular dilation with severe loss of central coaptation of the mitral leaflets</td>
<td>Regurgitant volume ≥60 mL</td>
<td>LV dilation and systolic dysfunction due to primary myocardial disease</td>
<td>Decreased exercise tolerance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Regurgitant fraction ≥50%</td>
<td>Exertional dyspnea</td>
<td></td>
</tr>
</tbody>
</table>
Why is Defining Mechanism Important?

- Primary (Organic) and Secondary (Functional) MR are two different diseases
  - Different natural history / prognosis
  - Treatment recommendations and options are different
    - Especially true for non-surgical therapies (e.g. MitraClip is approved for selected patients with Primary MR, not secondary MR)
    - Surgical approaches (repair vs replacement) are different
    - For Primary MR: Valve repair favored over replacement
    - Best treatment for Secondary MR remains uncertain
      - Reducing / eliminating MR is not curative
        - MR is one piece of the problem (LV dysfunction, primary heart muscle disease, CAD etc.)
          - No Class 1 indications for MV intervention
Primary vs Secondary MR

- Primary (organic) MR
  - A disease of the valve (fix the valve, potentially “cure” the disease)
    - MVP / Barlow’s
    - FED
    - Endocarditis
    - CTD
    - RHD
    - Radiation
    - Clefts / congenital

- Secondary (functional) MR
  - A disease of the ventricle (“fixing” the valve does not cure the underlying disease)
    - Valve is usually structurally normal
      - LV dysfunction (ICMP, NIMCP):
        - LV dilates, papillary muscle displacement, leaflet tethering
      - RWMA (esp inferolateral wall)
      - Annular dilation (dilated LV, Afib)
Considerations in Staging of Primary vs Secondary MR

- **Primary (organic) MR**
  - Emphasis is on valve anatomy
  - Qualitative and quantitative assessment of severity
  - Secondary effects on LA and LV
  - Symptoms ascribed to the MR (CHF, etc)

- **Secondary (functional) MR**
  - Valve anatomy is normal (impaired mobility)
  - Only quantitative assessment of severity
  - Primary anatomic / functional abnormalities of the LV
  - Symptoms often due to underlying CAD or LV dysfunction
Indications for Surgery / Intervention Depend on Stage and Type of MR

**PRIMARY MR**
- **Class I**
  - Stage D (EF > 30%)
  - Stage C2
  - Repair > Replace
- **Class IIa**
  - Stage C1
  - Stage B (with other surgery)
- **Class IIb**
  - Stage D (EF ≤30%)
  - TMV Repair (Stage D prohibitive surgical risk)
- **Class III**
  - MV Replacement (unless repair unsuccessful)

**SECONDARY MR**
- **Class I**
- **Class IIa**
  - Stage C/D (with other surgery)
  - MV Replacement (Stage D ischemic MR)*
- **Class IIb**
  - Stage D (repair or replace – non ischemic)*
  - Stage B (repair, with other surgery)
* Symptoms despite GDMT for CHF
How Do I Define the Mechanism of MR?
Decision Tree for Defining The Mechanism of MR: Primary vs Secondary MR

Evaluate mitral valve morphology, LV size and function, LA size
- Trace or mild MR is common in normal subjects and does not need to be further classified if above are normal
- Dilated LV/abnormal LVEF or dilated LA could be cause or consequence of MR
- An isolated inferolateral or posterobasal wall motion abnormality (e.g., following an MI) with globally preserved LV function can result in secondary MR
- Dilated LV with normal LVEF suggests severe MR
- Flail leaflet is highly specific for severe MR

Define Leaflet Motion (Carpentier Classification)

Type I
- Normal

Type II
- Prolapse or Flail

Type II A
- Restricted in both systole and diastole

Type II B
- Restricted in systole only

Abnormal Leaflet Morphology

Normal Leaflet Morphology

Abnormal Leaflet Morphology by Definition

Abnormal Leaflet Morphology

Normal Leaflet Morphology (minor age-related thickening allowed)

Secondary (atrial functional) MR

Mixed Etiology
- Example: known secondary MR due to ischemic cardiomyopathy with new torn chord and flail leaflet
- Common Pitfall: anterior leaflet override due to posterior leaflet restriction is pure secondary MR and NOT mixed etiology

Primary MR

Secondary MR
Steps in Defining The Mechanism of MR: Evaluate MV, LV and LA

- Describe MV anatomy in detail
  - Thickening, calcification, redundancy, flail, vegetations, perforations, chordal rupture
  - Annulus
  - Submitral apparatus

- LV findings
  - Organic MR with normal LV / LA unlikely to be severe

- Normal MV anatomy suggests secondary MR
  - Mechanism: LV dilation, RWMA, atrial enlargement
Steps in Defining The Mechanism of MR: Define Leaflet Motion and Morphology

Carpentier Classification

- Type 1 (Normal Motion)
  - Endocarditis, perforation, clefts (primary MR)
  - Normal anatomy (atrial secondary MR)

- Type II (Excessive Motion)
  - Prolapse / flail (primary MR)

- Type IIIA (Motion restricted in systole / diastole)
  - RHD, radiation, drugs, inflammatory disease (primary MR)

- Type IIIB (Motion restricted in systole)
  - Normal leaflets usually with ischemic / dilated CMP (secondary MR)
  - Abnormal leaflets such as partial flail / torn chordae (mixed MR)
Steps in Defining The Mechanism of MR: Classify as Primary, Secondary or Mixed

- **Primary MR**
  - Abnormal leaflets (Type I, II, IIIA)

- **Secondary MR**
  - Normal leaflets (Type I or IIIB)

- **Mixed MR**
  - Primary MR with secondary LV dilation / dysfunction (e.g. untreated chronic MR, intervening infarct with RWMA)
  - Secondary MR with subsequent leaflet disruption (e.g. chordal / papillary muscle rupture)
Common Pitfall / Misclassification

- “Anterior leaflet override due to posterior leaflet restriction is pure secondary MR and NOT mixed etiology.”
  2017 Consensus Statement (JACC 2017; 70: 2421)

- “...a severely restricted posterior leaflet due to ischemic wall motion abnormality may result in anterior leaflet override. In such cases, the anterior leaflet is not prolapsed and this does not represent a mixed etiology.”
  2017 ASE Native Valve Regurgitation Guidelines (JASE 2017;30:303)
How Do I Define the Mechanism of MR?

Other Clues

- Color Doppler jet direction
  - Anteriorly directed jet
    - Posterior leaflet prolapse / flail (common) or anterior leaflet restriction (not common)
  - Posteriorly directed jet
    - Anterior leaflet prolapse / flail or posterior leaflet restriction (common with functional MR)
  - Central jet
    - Common in secondary MR (dilated CMP), can be seen in primary MR

- PISA
  - Hemispheric (primary)
  - Not hemispheric (secondary)

- Continuous Wave Doppler
  - May be mid-late systolic (primary MR in MVP)
  - Holosystolic / uniform density (secondary MR with RWMA)
  - Biphasic density with mid-systolic dropout (dilated CMP with global dysfunction)
### Table 6 MV apparatus, cardiac remodeling, and jet characteristics in primary and secondary MR

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Primary MR</th>
<th>Secondary MR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Myxomatous or calcific leaflet degeneration</td>
<td>Inferior myocardial infarction</td>
</tr>
<tr>
<td>LV remodeling</td>
<td>Global, if severe chronic MR</td>
<td>Primarily inferior wall</td>
</tr>
<tr>
<td>LA remodeling</td>
<td>Moderate to severe if chronic MR</td>
<td>Variable</td>
</tr>
<tr>
<td>Annulus</td>
<td>Dilated, preserved dynamic function</td>
<td>Mild to no dilation, less dynamic</td>
</tr>
<tr>
<td>Leaflet morphology:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickening</td>
<td>Yes/moderate, severe</td>
<td>No/mild</td>
</tr>
<tr>
<td>Prolapse or flail</td>
<td>Usually present</td>
<td>No</td>
</tr>
<tr>
<td>Calcification</td>
<td>Variable</td>
<td>No/mild</td>
</tr>
<tr>
<td>Tethering pattern</td>
<td>None</td>
<td>Asymmetric</td>
</tr>
<tr>
<td>Systolic tenting</td>
<td>None</td>
<td>Increased</td>
</tr>
<tr>
<td>Papillary muscle distance</td>
<td>Normal</td>
<td>Increased posterior papillary-intervallar fibrosa distance</td>
</tr>
<tr>
<td>MR jet direction</td>
<td>Eccentric or central</td>
<td>Posterior</td>
</tr>
<tr>
<td>CWD</td>
<td>May be late systolic (if MVP) or uniform if flail or with calcific degeneration</td>
<td>Density usually uniform throughout systole</td>
</tr>
<tr>
<td>PISA</td>
<td>Often hemispheric</td>
<td>Often not hemispheric</td>
</tr>
</tbody>
</table>

*Primary and secondary MR may coexist.
ASSESSING SEVERITY QUANTIFICATION OF MITRAL VALVE REGURGITATION WHY, HOW and WHEN?

- WHY SHOULD I QUANTIFY VALVE REGURGITATION?

- WHY DON’T WE QUANTIFY VALVE REGURGITATION?

- TOOLS TO QUANTIFY VALVE REGURGITATION (MR)
  - WHAT IS QUANTIFICATION OF MR?

- WHEN SHOULD YOU QUANTIFY VALVE REGURGITATION?
Why is Echo Quantification of MR Important?

- Staging and subsequent treatment recommendations depend on an accurate assessment of the degree of MR
  - Staging of both Primary and Secondary MR guided by quantitative measures
    - Only quantitative methods are recommended for secondary MR
  - Staging also involves an accurate evaluation of valve anatomy, hemodynamic consequences (LA, LV, PASP) and symptom assessment
- Color Flow Doppler (Qualitative) has many limitations
- Echocardiographic assessment has supplanted the invasive assessment of MR
<table>
<thead>
<tr>
<th>Grade</th>
<th>Definition</th>
<th>Valve Anatomy</th>
<th>Valve Hemodynamics*</th>
<th>Hemodynamic Consequences</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>At risk of MR</td>
<td>Mild mitral valve prolapse with normal coaptation</td>
<td>No MR jet or small central jet area (&lt;20% LA on Doppler) Small vena contracta (&lt; 0.3 cm)</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>B</td>
<td>Progressive MR</td>
<td>Severe mitral valve prolapse with normal coaptation Rheumatic valve changes with leaflet restriction and loss of central coaptation Prior IE</td>
<td>Central jet MR 20%–40% LA or late systolic eccentric jet MR Vena contracta (&gt; 0.7 cm) Regurgitant volume 50%–&gt;80 mL Regurgitant fraction (&lt;50% ERO 0.40 cm² Angiographic grade 1–2+</td>
<td>Mild LA enlargement No LV enlargement Normal pulmonary pressure</td>
<td>None</td>
</tr>
<tr>
<td>C</td>
<td>Asymptomatic severe MR</td>
<td>Severe mitral valve prolapse with loss of coaptation or flail leaflet Rheumatic valve changes with leaflet restriction and loss of central coaptation Prior IE Thickening of leaflets with radiation heart disease</td>
<td>Central jet MR 40%–60% LA or holosystolic eccentric jet MR Vena contracta (&lt; 0.7 cm) Regurgitant volume 60 mL Regurgitant fraction (&gt;50% ERO 0.40 cm² Angiographic grade 3–4+</td>
<td>Moderate or severe LA enlargement LV enlargement Pulmonary hypertension may be present at rest or with exercise C1: LVEF &lt;60% and LVESD &lt;40 mm C2: LVEF ≤60% and LVESD ≥40 mm</td>
<td>None</td>
</tr>
<tr>
<td>D</td>
<td>Symptomatic severe MR</td>
<td>Severe mitral valve prolapse with loss of coaptation or flail leaflet Rheumatic valve changes with leaflet restriction and loss of central coaptation Prior IE Thickening of leaflets with radiation heart disease</td>
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<td>Moderate or severe LA enlargement LV enlargement Pulmonary hypertension present</td>
<td>Decreased exercise tolerance Exertional dyspnea</td>
</tr>
</tbody>
</table>

*Several valve hemodynamic criteria are provided for assessment of MR severity, but not all criteria for each category will be present in each patient. Categorization of MR severity as mild, moderate, or severe depends on data quality and integration of these parameters in conjunction with other clinical evidence.

ERO indicates effective regurgitant orifice; IE, infective endocarditis; LA, left atrium/atrial; LV, left ventricular; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic dimension; and MR, mitral regurgitation.

Nishimura et al. ACC / AHA Valve Guidelines 2014
### Stages of Secondary MR
(Updated from 2014 Guideline)

**JACC 2017;70:252**

#### TABLE 2
**Stages of Secondary MR (Table 16 in the 2014 VHD Guideline)**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Definition</th>
<th>Valve Anatomy</th>
<th>Valve Hemodynamics*</th>
<th>Associated Cardiac Findings</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>At risk of MR</td>
<td>Normal valve leaflets, chords, and annulus in a</td>
<td>No MR jet or small</td>
<td>Normal or mildly dilated LV</td>
<td>Symptoms due to coronary ischemia or HF may be present that respond to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>patient with coronary disease or cardiomyopathy</td>
<td>central jet area &lt;20%</td>
<td>size with fixed (infarction)</td>
<td>revascularization and appropriate medical therapy</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>LA on Doppler</td>
<td>(ischemia) regional wall motion</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Small vena contracta</td>
<td>abnormalities</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;0.30 cm</td>
<td>Primary myocardial disease</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>with LV dilation and systolic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>dysfunction</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Progressive MR</td>
<td>Regional wall motion abnormalities with mild tethering</td>
<td>ERO &lt;0.40 cm²</td>
<td>Regional wall motion</td>
<td>Symptoms due to coronary ischemia or HF may be present that respond to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of mitral leaflet</td>
<td>Regurgitant volume</td>
<td>abnormalities with reduced</td>
<td>revascularization and appropriate medical therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;60 mL</td>
<td>LV systolic function</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Regurgitant fraction</td>
<td>LV dilation and systolic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;50%</td>
<td>dysfunction due to primary myocardial disease</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Asymptomatic severe MR</td>
<td>Regional wall motion abnormalities and/or LV dilation</td>
<td>ERO ≥0.40 cm²</td>
<td>Regional wall motion</td>
<td>Symptoms due to coronary ischemia or HF may be present that respond to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>with severe tethering of mitral leaflet</td>
<td>Regurgitant volume</td>
<td>abnormalities with reduced</td>
<td>revascularization and appropriate medical therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥60 mL</td>
<td>LV systolic function</td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td>Regurgitant fraction</td>
<td>LV dilation and systolic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥50%</td>
<td>dysfunction due to primary myocardial disease</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Symptomatic severe MR</td>
<td>Regional wall motion abnormalities and/or LV dilation</td>
<td>ERO ≥0.40 cm²</td>
<td>Regional wall motion</td>
<td>HF symptoms due to MR persist even after revascularization and optimization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>with severe tethering of mitral leaflet</td>
<td>Regurgitant volume</td>
<td>abnormalities with reduced</td>
<td>of medical therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥60 mL</td>
<td>LV systolic function</td>
<td>Decreased exercise tolerance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Regurgitant fraction</td>
<td>LV dilation and systolic</td>
<td>Exertional dyspnea</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥50%</td>
<td>dysfunction due to primary myocardial disease</td>
<td></td>
</tr>
</tbody>
</table>

**QUANTITATIVE MEASURES FOR ERO AND RV ARE NOW CONCORDANT WITH PRIMARY MR RECOMMENDATIONS**

**ONLY QUANTITATIVE MEASURES ARE RECOMMENDED AND THESE PARAMETERS DIFFERENTIATE STAGE B / C**
Should Quantitative Parameters Differ Between Primary and Secondary MR?

- In 2014 guidelines there were different (lower) quantitative cut-offs for secondary MR using PISA ERO and Regurgitant Volume
  - Since LV is impaired in secondary MR, a smaller regurgitant volume or ERO may have greater (adverse) impact on outcome
  - Severity may increase over time as LV continues to remodel / EF drops in secondary MR
  - Doppler assessment (PISA ERO) may be less accurate in secondary MR

- 2017 Update made cut-offs concordant
  - ERO > 0.2 cm² is more sensitive, an ERO > 0.4 cm² is more specific for severe secondary MR
Hemodynamic Considerations With Chronic MR

- MR can be dynamic
  - Changes in loading conditions
    - BP, effects of sedation / anesthesia, volume status, ischemia
  - Severity can vary during systole (assuming constant flow or constant regurgitant orifice may overestimate MR severity)
    - MVP (mid-late systole)
    - Secondary MR (biphasic)
    - SAM (HCMP, post MV repair)
      - MR may change with volume status, LV contractility
  - Rhythm and Pacing
    - RV pacing can induce dyssynchrony (increases MR)
    - Atrial fibrillation
      - Variable MR depending on cycle length, changes in LV volume / contractility
QUANTIFICATION OF VALVE DISEASE

- ROUTINELY QUANTIFY VALVE STENOSIS
  - AORTIC STENOSIS
    - MEAN GRADIENT
    - VALVE AREA
  - WE DON’T “EYEBALL” AS

- WHY NOT FOR VALVE INSUFFICIENCY?
  - Why are we comfortable “eyeballing” MR??
Why Do We Not Quantify MR?

- Lack of training / knowledge
- Not thought to be important ("eyeball" is good enough)
- We do not believe the Echo techniques
- Time Consuming
- Challenges in Grading the Severity of Valve Regurgitation
  - What is the Gold Standard?
    - Angiographic Grades vs Quantitative (invasive) grades compared to Echo / MRI
    - Variability of severity depending on hemodynamics
- Time constraints and financial dis-incentives
  - “Severe MR” gets paid the same as “There is severe primary MR. The mitral valve is myxomatous with a flail P2 segment. The VC is 0.8 cm, the ERO is 0.45 cm² with a regurgitant volume of 63 cc. Compared to the last study, the P2 flail is new and the MR is now severe”
Why Do We Not Quantify MR?

- Lack of training / knowledge
- Not thought to be important ("eyeball" is good enough)
- We do not believe the Echo techniques
- Time Consuming
- Challenges:
  - What is the Gold Standard?
  - Angiographic Grades vs Quantitative (invasive) Grades
  - Variability of severity depending on hemodynamics
- Time constraints and financial disincentives

"Severe MR gets paid the same as there is severe primary MR. The mitral valve is myxomatous with a flail P2 segment. The VC is 0.8 cm, the ERO is 0.45 cm² with a regurgitant volume of 63 cc. Compared to the last study, the P2 flail is new and the MR is now severe"
ECHO ASSESSMENT OF MITRAL VALVE INSUFFICIENCY

STRUCTURAL PARAMETERS
- VALVE ANATOMY (Classification of disease)
- ATRIAL / VENTRICULAR SIZE (consequences of disease, etiology of MR)

DOPPLER PARAMETERS
- SPECTRAL DOPPLER
  - TMF E WAVE
  - PV DOPPLER PATTERN
  - DENSITY / SHAPE OF MR JET
- COLOR DOPPLER
  - JET AREA
  - VENA CONTRACTA
  - FLOW CONVERGENCE ZONE

ERO (PISA)

REGURGITANT VOLUME / FRACTION
# ASE GUIDELINES FOR ASSESSING MR

## Advantages and Limitations

Table 2 Echocardiographic and Doppler parameters used in the evaluation of mitral regurgitation severity: Utility, advantages, and limitations

<table>
<thead>
<tr>
<th>Structural parameters</th>
<th>Utility/advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA and LV Size</td>
<td>Enlargement sensitive for chronic significant MR, important for outcomes. Normal size virtually excludes significant chronic MR.</td>
<td>Enlargement seen in other conditions. May be normal in acute significant MR.</td>
</tr>
<tr>
<td>MV leaflet/support apparatus</td>
<td>Flail valve and ruptured papillary muscle specific for significant MR</td>
<td>Other anomalies do not imply significant MR.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Doppler parameters</th>
<th>Utility/advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jet area–Color Flow</td>
<td>Simple, quick screen for mild or severe central MR; evaluates spatial orientation of jet</td>
<td>Subject to technical, hemodynamic variation; significantly underestimates severity in wall-impinging jets</td>
</tr>
<tr>
<td>Vena contracta width</td>
<td>Simple, quantitative, good at identifying mild or severe MR</td>
<td>Not useful for multiple MR jets; intermediate values require confirmation. Small values; thus small error leads to large % error</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PISA method</th>
<th>Utility/advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantitative; Presence of flow convergence at Nyquist limit of 50–60 cm/s alerts to significant MR. Provides both lesion severity (EROA) and volume overload (R Vol)</td>
<td>Less accurate in eccentric jets; not valid in multiple jets. Provides peak flow and maximal EROA.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow quantitation–PW</th>
<th>Utility/advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantitative, valid in multiple jets and eccentric jets. Provides both lesion severity (EROA, RF) and volume overload (R Vol)</td>
<td>Measurement of flow at MV annulus less reliable in calcific MV and/or annulus. Not valid with concomitant significant AR unless pulmonic site is used.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Jet profile–CW</th>
<th>Utility/advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple, readily available</td>
<td>Qualitative; complementary data. Influenced by LA pressure, LV relaxation, MV area, and atrial fibrillation. Complementary data only, does not quantify MR severity.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Peak mitral E velocity</th>
<th>Utility/advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple, readily available, A-wave dominance excludes severe MR</td>
<td>Influenced by LA pressure, atrial fibrillation. Not accurate if MR jet directed into the sampled vein</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pulmonary vein flow</th>
<th>Utility/advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple, Systolic flow reversal is specific for severe MR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Zoghbi et al JASE 2003:16: 777
WHAT ECHOCARDIOGRAPHIC TOOLS ARE AVAILABLE TO ASSESS MR SEVERITY?

- QUALITATIVE
- SEMI-QUANTITATIVE
- QUANTITATIVE METHODS
WHAT QUALITATIVE TOOLS ARE AVAILABLE TO ASSESS MR?

- QUALITATIVE
  - LA SIZE / LV SIZE
  - DENSITY OF MR JET
  - CONTOUR OF MR JET
  - PV DOPPLER PATTERN
  - E wave VELOCITY
  - A WAVE DOMINANCE (severe MR unlikely)

Zoghbi et al JASE 2017;30:303 Fig 12
WHAT SEMI-QUANTITATIVE TOOLS ARE AVAILABLE TO ASSESS MR?

- SEMI-QUANTITATIVE
  - COLOR JET AREA
    - MULTIPLE LIMITATIONS
  - VENA CONTRACTA
  - FLOW CONVERGENCE (PISA)

Figure 1 Color flow recording of a mitral regurgitation jet obtained from a zoomed view in the parasternal long axis depicting the 3 components of the regurgitant jet: flow convergence, vena contracta (VC), and jet area in the left atrium. Measurement of the vena contracta is shown between the red arrow.

Zoghbi et al JASE 2003:16: 777
WHAT QUANTITATIVE TOOLS ARE AVAILABLE TO ASSESS MR?

- QUANTITATIVE MEASURES
  - EROA (PISA and DOPPLER)
  - REGURGITANT VOLUME
    - PISA
  - QUANTITATIVE ASSESSMENT OF STROKE VOLUME AND REGURGITANT VOLUME
    - DOPPLER VOLUMES
    - 2 / 3 D VOLUMES
  - REGURGITANT FRACTION

Flow Convergence Method

\[
\text{Reg Flow} = 2\pi r^2 \times V_a
\]

\[
\text{EROA} = \frac{\text{Reg Flow}}{\text{PkJV}_{\text{Reg}}}
\]

Figure 2 Schematic depiction of the flow convergence or proximal isovelocity surface area (PISA) method for quantitating mitral regurgitation. 1. Mitral regurgitant jet visualized by color Doppler convergence toward the 4 Leaflet. 2. Isovelocity surface area (PISA) the area, determined by continuous wave Doppler. Reg flow, regurgitant flow; EROA, effective regurgitant orifice area; Reg jet, regurgitation jet.

Figure 8.11. This schematic demonstrates the principle of conservation of mass. In the absence of valvar regurgitation or intracardiac shunts, the stroke volume through each of the four valves is equal to the stroke volume of the saline or water valve; MV, mitral valve; PV, pulmonic valve; TV, tricuspid valve; AV, aortic valve.
ASSESSMENT OF MR SEVERITY
Color Flow Doppler

- Primary tool to screen for MR
  - Absence of a color Doppler jet excludes MR
  - Caveat: acoustic shadowing of the LA
- Three measurements (qualitative / semi-quantitative)
  - Regurgitant jet area
  - Vena Contracta
  - Flow Convergence
ASSESSMENT OF MR SEVERITY COLOR FLOW DOPPLER (Jet Area)

- Probably the most widely used measure
- Very qualitative
- Many limitations
  - Affected by instrument settings
  - Affected by hemodynamics
    - For a given ERO, a high velocity jet will appear larger than a lower velocity jet
      - A 6 m/s MR jet is 44% larger than a 5 m/s jet
      - AS, uncontrolled hypertension will result in larger jets
    - MR color jets in the setting of low driving pressure (e.g. severe LV dysfunction) often appear small and underestimate severity
    - Eccentric jets appear smaller (Coanda effect) and underestimate severity
ASSESSMENT OF MR SEVERITY
COLOR FLOW DOPPLER (Jet Area)

- Appearance can depend on mechanism
  - Flail leaflet: eccentric jet (small, underestimates severity)
  - Central slit like jets in secondary MR can overestimate severity
    - Large in 2 chamber / commissural view
- Color Jet area alone (even indexed to LA) should NOT be used in isolation to assess MR severity
  - Assess jet origin (VC / Flow convergence)
- A small non eccentric jet with a small VC and no flow convergence usually indicates mild MR
- A large jet with a wide VC, large flow convergence, that wraps around the LA and penetrates deep in to the PV is almost always severe MR
### Table 2 Factors that increase or reduce the color Doppler jet area

<table>
<thead>
<tr>
<th>Increases jet area</th>
<th>Reduces jet area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher momentum</td>
<td>Lower momentum</td>
</tr>
<tr>
<td>Larger regurgitant orifice area</td>
<td>Smaller regurgitant orifice area</td>
</tr>
<tr>
<td>Higher velocity (greater pressure gradient)</td>
<td>Lower velocity (lower pressure gradient)</td>
</tr>
<tr>
<td>Higher entrainment of flow</td>
<td>Chamber constraint/wall-impinging jet</td>
</tr>
<tr>
<td>Lower Nyquist limit</td>
<td>Higher Nyquist limit</td>
</tr>
<tr>
<td>Higher Doppler gain</td>
<td>Lower Doppler gain</td>
</tr>
<tr>
<td>Far-field beam widening</td>
<td>Far-field attenuation/attenuation by an interposed ultrasound-reflecting structure</td>
</tr>
<tr>
<td>Slit-like regurgitant orifice, imaged along the thin, long shape of the orifice</td>
<td></td>
</tr>
<tr>
<td>Multiple orifices</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2** Effect of color gain, Nyquist limit, and transducer frequency on color jet area. Color gain should be optimized high.
ASSESSMENT OF MR SEVERITY
COLOR FLOW DOPPLER (Vena Contracta)

- Semi-quantitative
- Independent of flow rate / driving pressure
- Estimation of the EROA (smaller than the ARO)
  - Zoom of PLAX (A3ch is alternative)
    - Measure narrowest diameter as jet emerges from orifice
    - VC < 0.3 cm mild MR
    - VC ≥ 0.7 cm severe MR
    - Intermediate values require further evaluation
- Not accurate with multiple jets / elliptical orifices / dynamic orifices
- 3 D VC area using MPRs and direct planimetry
ASSESSMENT OF MR SEVERITY
COLOR FLOW DOPPLER (Flow Convergence or PISA)

- More accurate for central jets and circular orifices
- Challenging to determine exact location of orifice
- PISA can vary over the cardiac cycle
- Crescent shape orifice (often seen in functional MR) may result in underestimation of MR
  - Lower cut-off values may be appropriate
- A small or non existent FC with a small jet is specific for mild MR
- A large FC that persists throughout systole is specific for severe MR
- FC data can be used to quantitate regurgitant flow
ASSESSMENT OF MR SEVERITY
Continuous Wave Doppler as a Qualitative Measure

- Spectral density is proportionate to the # of rbc’s reflecting the Doppler signal
- Timing / duration of jet reflects underlying hemodynamics
  - Jets that are not holosystolic reflect less volume
    - Predominate early systolic jets with CMP / dyssynchrony
    - Mid-late systolic jets with MVP
  - Non parabolic (early peaking or cutoff sign) suggests a large V wave
- Peak velocity does NOT reflect severity of MR
  - May reflect hemodynamic consequences
    - Low velocity (<4m/s) with low BP or high LAP
ASSESSMENT OF MR SEVERITY
Pulsed Doppler as a Qualitative Measure

- TMF E and A velocity
  - Increased Ev (>1.2m/s) and E/A ratio suggest significant MR
  - A wave predominance not consistent with severe MR
  - Multiple limitations (presence of MS, DD, MV ring, severe MAC)
  - In secondary MR, confounded by influence of elevated filling pressures

- PV flow patterns
  - As MR increases in severity, systolic flow is progressively blunted
  - Systolic flow reversal is specific but not sensitive
  - Confounded by effect of filling pressures

Zoghbi JASE 2017;30:303
Doppler Quantitation of MR

- **EROA**
  - PISA methodology

- **Regurgitant volume**
  - Can be calculated using PISA combined with CW Doppler
    - \( ERO \times VTI_{MR} \)
  - Can be calculated with Doppler assessment of forward stroke volume and total mitral valve stroke volume (or 2 D / 3 D derived volumes)

- **Regurgitant Fraction**
  - Can be calculated with Doppler assessment of regurgitant volume and total stroke volume (or 2 D / 3 D derived volumes)
Flow Convergence (PISA) Derived ERO

- Baseline shift in direction of flow
  - Down on TTE
  - Up on TEE
- Calculate the ERO as well as the Rvol
- Many limitations
  - Timing of measurements
  - Duration (if not holosystolic)
  - Shape of PISA
  - Shape of RO
  - Eccentric jets (hard to align Doppler)
  - Multiple jets

Reg Flow = \(2\pi r^2 \times V_a\)
EROA = \(\text{Reg Flow/ PKV}_{\text{Reg}}\)
R Vol = EROA \times VTI_{\text{Reg}}
WHAT TOOLS ARE AVAILABLE TO ASSESS MR?

QUANTITATIVE METHODS TO ASSESS VOLUMES

Calculating Stroke Volume and Regurgitant Volume

- **DOPPLER METHODS**
  - **PW DOPPLER**
    \[ SV_{valve} = \pi d^2/4 \times VTI_{valve} \]
    - **REQUIRES ONE VALVE WITHOUT (SIGNIFICANT) REGURGITATION**
    \[ RV = SV_{REG\ VALVE} - SV_{COMP\ VALVE} \]

- **2D/3D METHODS**
  - **TOTAL SV FROM LV ED VOL – LV ES VOL**
    \[ RV = \text{TOTAL SV} - SV_{COMP\ VALVE} \]
  - **EROA = Rvol / VTI_{mr\ jet}**
DOPPLER CALCULATION OF SV, RV and RF for MR

Measurement error in any one of these 4 parameters can occur

Assumes a circular orifice

Feigenbaum 6th Ed, page 220

\[
SV_{LVOT} = \pi (LVOTd/2)^2 \cdot VTI_{LVOT} = 58 \text{ cc} \\
SV_{MV} = \pi (MVd/2)^2 \cdot VTI_{MV inflow} = 183 \text{ cc} \\
RVol = 183 - 58 = 125 \text{ cc} \\
RF = 125/183 = 68 \%
\]
 CALCULATION OF REGURGITANT FRACTION

Mitral Regurgitant Fraction (Doppler)
\[
\text{MV stroke volume} - \text{AV stroke volume} \\
\text{MV stroke volume}
\]

Mitral Regurgitant Fraction (2/3D volumes)
\[
\text{LV stroke volume} - \text{AV stroke volume} \\
\text{LV stroke volume}
\]
### Table 8 Grading the severity of chronic MR by echocardiography

<table>
<thead>
<tr>
<th>MR severity*</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structural</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MV morphology</td>
<td>None or mild leaflet abnormality (e.g., mild thickening, calcifications or prolapse, mild tenting)</td>
<td>Moderate leaflet abnormality or moderate tenting</td>
<td>Severe valve lesions (primary: fail leaflet, ruptured papillary muscle, severe retraction, large perforation; secondary: severe tenting, poor leaflet coaptation)</td>
</tr>
<tr>
<td>LV and LA size†</td>
<td>Usually normal</td>
<td>Normal or mild dilated</td>
<td>Dilated‡</td>
</tr>
</tbody>
</table>

**Qualitative Doppler**

<table>
<thead>
<tr>
<th>Color flow jet area§</th>
<th>Small, central, narrow, often brief</th>
<th>Variable</th>
<th>Large central jet (&gt;50% of LA) or eccentric wall-impinging jet of variable size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow convergence†</td>
<td>Not visible, transient or small</td>
<td>Intermediate in size and duration</td>
<td>Large throughout systole</td>
</tr>
<tr>
<td>CWD jet</td>
<td>Faint/parial/parabolic</td>
<td>Dense but partial or parabolic</td>
<td>Holosystolic/dense triangular</td>
</tr>
</tbody>
</table>

**Semi-quantitative**

<table>
<thead>
<tr>
<th>Vcw (cm)</th>
<th>&lt;0.3</th>
<th>Intermediate</th>
<th>≥0.7 (&gt;0.8 for bipiane)§</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary vein flow*</td>
<td>Systolic dominance (may be blunted in LV dysfunction or AF)</td>
<td>Normal or systolic blunting*</td>
<td>Minimal to no systolic flow/ systolic flow reversal</td>
</tr>
<tr>
<td>Mitral inflow**</td>
<td>A-wave dominant</td>
<td>Variable</td>
<td>E-wave dominant (&gt;1.2 m/sec)</td>
</tr>
</tbody>
</table>

**Quantitative**

<table>
<thead>
<tr>
<th>EROA, 2D PISA (cm²)</th>
<th>&lt;0.20</th>
<th>0.20-0.29</th>
<th>0.30-0.39</th>
<th>≥0.40 (may be lower in secondary MR with elliptical ROA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVol (mL)</td>
<td>&lt;30</td>
<td>30-44</td>
<td>45-59†</td>
<td>≥60 (may be lower in low flow conditions)</td>
</tr>
<tr>
<td>RF (%)</td>
<td>&lt; 30</td>
<td>30-39</td>
<td>40-49</td>
<td>≥50</td>
</tr>
</tbody>
</table>
When Should I Quantitate MR?

Figure 18
Algorithm for the integration of multiple parameters of MR severity. Good-quality echocardiographic imaging and comprehensive interpretation may be necessary to achieve accurate and reliable quantitation of MR severity.

- Beware 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 and Vcw overestimate non-holosystolic MR.
- Regurgitant volume for severe MR may be lower in low flow conditions.

Specific Criteria for Mild MR:
- Small, narrow central jet
- Vcw ≤ 0.3 cm
- PISA radius absent or ≤ 0.3 cm at Nyquist 30-40 cm/s
- Mitral A wave dominant inflow
- Severe or incomplete jet by CW Doppler
- Normal LV and LA size

Specific Criteria for Severe MR:
- Fast leak
- Vcw > 0.7 cm
- PISA radius > 1.0 cm at Nyquist 30-40 cm/s
- Central large jet > 50% of LA area
- Pulmonary vein systolic flow reversal
- Enlarged LV with normal function
When Should I (Perhaps) NOT Quantitate MR?

INITIAL ASSESSMENT SUGGESTS MINIMAL / MILD MR

- SMALL COLOR JET AREA, VCW < 0.3 cm, NO FLOW CONVERGENCE, NORMAL LA / LV SIZE, PW AND CW DOPPLER (A wave predominance, soft or incomplete MR jet)

INITIAL ASSESSMENT SUGGESTS SEVERE MR

- LARGE VCW > 0.7 cm, LARGE JET AREA, LARGE FLOW CONVERGENCE (radius > 1 cm), FLAIL LEAFLET / LACK OF LEAFLET COAPTATION, SPECTRAL DOPPLER E wave predominance, PV flow reversal, DILATED LV WITH NORMAL EF
WHEN SHOULD I QUANTIFY MR?

- WHEN CLINICAL DECISION MAKING HINGES ON AN ACCURATE ASSESSMENT OF MR SEVERITY
  - ESPECIALLY IN THE ASYMPTOMATIC PATIENT
- IN “2-3+” MR PATIENTS
- INTERMEDIATE / MIXED QUALITATIVE / SEMIQUANTITATIVE FINDINGS
  - CAN HELP TO DOWNGRADE or UPGRADE
- WHEN CLINICAL SYMPTOMS AND ECHO FINDINGS ARE DISCORDANT
When Should I Quantitate MR?
CHRONIC MR: A REAL CASE
MILD, MODERATE OR SEVERE

Primary, Secondary or Mixed?
Mild, Moderate or Severe?

ERO = \( 2\pi (0.5)^2 \times 39 = 0.13 \text{ cm}^2 \)
CHRONIC MR: ANOTHER REAL CASE
MILD, MODERATE OR SEVERE

Primary, Secondary or Mixed?
Mild, Moderate or Severe?

\[ ERO = 2\pi (1.1)^2 \times 34 = 0.49 \text{ cm}^2 \]
HOW SHOULD I QUANTIFY MITRAL REGURGITATION?
WHAT TOOLS ARE AVAILABLE?

- ECHOCARDIOGRAPHY
  - INITIAL EVALUATION
  - PRIMARY CLINICAL TOOL
- CARDIAC MRI
  - IMPORTANT SECONDARY TOOL
- CATHETERIZATION / ANGIOGRAPHY
  - LIMITED ROLE
Putting it All Together

- Clinical scenario
- Symptoms
- Physical Exam
- Echocardiography
  - Description of valve anatomy and mechanism (primary vs secondary)
  - LA and LV assessment
  - Assessment of Severity
    - Qualitative measures
    - Semi-quantitative measures
    - Quantitative measures
      - VC
      - ERO (PISA)
      - CALCULATE RV / RF
- Integrative approach
  - All Echo methods / parameters have limitations
  - Use all of the available tools
HELPFUL HINTS WITH PRIMARY MR

- Severe valve pathology (flail leaflet, ruptured papillary muscle, severe leaflet retraction or large perforation) is fairly specific for severe MR.
- VCW $\geq 0.7$ cm and PV systolic flow reversal are specific for severe MR.
- Lack of a FC zone or presence of A wave dominance are specific for nonsevere MR.
- Assess MR duration and character of MR jet.
  - Late systolic MR rarely severe.
  - Spectral MR jet is not dense suggests nonsevere MR.
- Normal LA volume usually precludes severe chronic MR as does normal PV flow.
HELPFUL HINTS WITH SECONDARY MR

- Can be more challenging to grade
- LV forward SV is often low, therefore RV may be lower than in primary MR
- Regurgitant orifice is often not circular, therefore VCW and PISA assumptions may not apply (may underestimate severity)
- Blunted systolic PV flow may reflect elevated LV filling pressures and not significant MR
- More dynamic than primary MR
SENDING THE PATIENT TO US
Sending Us the Patient for Evaluation

- Having the imaging data prior to initial evaluation is helpful
  - How to get us the information

- We often repeat evaluations (and may come up with different assessments)
  - MR can be very dynamic
  - Quantitative measures often override the qualitative assessment
  - Many of our trials require quantitative information or specific information about the LA, MV and atrial septal anatomy
MITRAL REGURGITATION
SUMMARY

- Defining the mechanism and type of MR is critical in the evaluation and management of the MR patient

- Assessment of the severity of MR requires an integrative approach and should incorporate qualitative, semi-quantitative and quantitative methods
  - Color jet area alone should NOT be used

- Echo reports should provide a comprehensive evaluation of the MV anatomy and degree of MR

- Clinical decision making requires a multi-disciplinary approach to management
ACCURATE ASSESSMENT OF THE MECHANISM AND SEVERITY OF MITRAL REGURGITATION IS ESSENTIAL IN DECISION MAKING

All Echo parameters have strengths and weaknesses
No one parameter should be used
An integrative approach is required
USE ALL OF THE AVAILABLE DATA TO ASSESS MITRAL REGURGITATION
THANK YOU