Hemodynamics of Functional Mitral Regurgitation

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Disclosure

• None
Outline

• Why MV is a special valve?
• What are the types of MR?
• What is FMR?
• How to interpret the hemodynamics of FMR?
• Pitfalls in MR hemodynamics interpretation
• Summary
MR

Acute

Chronic

Primary (Valve)

Degenerative

Rheumatic

Secondary (Ventricle)

Dilated (Central Jet)

Ischemic (Eccentric Jet)
Chronic mitral regurgitation

LV
LA

Acute mitral regurgitation

LV
LA

LV
LA

S1 S2 S3

S4 S1 S2 S3
Etiology of MR

- Degenerative: 65%
- Ischemic: 27%
- Endocarditis: 5%
- Rheumatic: 1%
- Others: 2%
Prevalence of MR based on Carpentier Classification in US Adults

- Type I: 10 per million
- Type II: 15170.5 per million
- Type IIIB: 16250 per million
- Unclassified: 9530 per million

J CARD SURG 2011;26:385-392
Revised Carpentier classification

MR Mechanism based on Leaflet motion by 2D echo

Normal – No MR

Apical Tethering (III B)

Excessive (II)

MR with Normal Leaflet Motion (I)

Restricted (III A)

JET: OPPOSITE SIDE

CENTRAL

SAME SIDE (OR CENTRAL)
## MR vs. AR

<table>
<thead>
<tr>
<th>Pathophysiology</th>
<th>MR</th>
<th>AR</th>
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<tbody>
<tr>
<td>Preload</td>
<td>Pure volume overload</td>
<td>Volume and pressure overload</td>
</tr>
<tr>
<td>Afterload</td>
<td>=</td>
<td>=</td>
</tr>
<tr>
<td>EF after OR</td>
<td>=</td>
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LV PV Loop in Chronic MR
PV Loop in Chronic MR

• No true IVC
• Regurgitation of blood from the LV to LA throughout ventricular systole
• Ventricular volumes & pressures are increased during diastole
• Increased preload but with reduced afterload
FMR Facts

- More common than primary MR
- Associated with a worse prognosis
- Benefits of MV surgery are uncertain
- FMR corresponds with the class I or IIIb types
- Distortion of LV geometry and function are key components in FMR
How FMR Happens?

- LV dysfunction and remodeling lead to apical and lateral papillary muscle displacement, resulting in:
  1. Leaflet tethering
  2. Dilation and flattening of the mitral annulus
  3. Reduced valve closing forces

- Dynamic MR = because these changes are dependent on loading conditions and the phase of the cardiac cycle
Correlation

- Physiology
- Physical Exam
- Echo
- Hemodynamics
FMR

• History and physical examination are insensitive for the diagnosis of FMR

• Physical examination might be unreliable for the presence of a mitral regurgitant murmur because:
  • Decreased LV pressures result in lower pressure gradients
Echo Hemodynamics

• How Does It Effect the Heart?
• What causes it?
• How much is there?
### Table 1: Stages of Secondary (Functional) MR

<table>
<thead>
<tr>
<th>Grade</th>
<th>Valve Anatomy</th>
<th>Valve Hemodynamics*</th>
<th>Cardiac Structure and Function</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: 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 Small vena contracta &lt;0.30 cm</td>
<td>Normal or mildly dilated LV size with fixed (infarction) or inducible (ischemia) regional wall motion abnormalities Primary myocardial disease with LV dilation and systolic dysfunction</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: Progressive MR</td>
<td>Regional wall motion abnormalities with mild tethering of mitral leaflet Annular dilation with mild loss of central coaptation of the mitral leaflets</td>
<td>EROA &lt;0.20 cm² Regurgitant volume &lt;30 ml Regurgitant fraction &lt;50%</td>
<td>Regional wall motion abnormalities with reduced LV systolic function LV dilation and systolic dysfunction due to primary myocardial disease</td>
<td>Symptoms due to coronary ischemia or HF may be present that respond to revascularization and appropriate medical therapy</td>
</tr>
<tr>
<td>C: Asymptomatic severe MR</td>
<td>Regional wall motion abnormalities and/or LV dilation with severe tethering of mitral leaflet Annular dilation with severe loss of central coaptation of the mitral leaflets</td>
<td>EROA ≥0.20 cm² Regurgitant volume ≥30 ml Regurgitant fraction ≥50%</td>
<td>Regional wall motion abnormalities with reduced LV systolic function LV dilation and systolic dysfunction due to primary myocardial disease</td>
<td>Symptoms due to coronary ischemia or HF may be present that respond to revascularization and appropriate medical therapy</td>
</tr>
<tr>
<td>D: Symptomatic severe MR</td>
<td>Regional wall motion abnormalities and/or LV dilation with severe tethering of mitral leaflet Annular dilation with severe loss of central coaptation of the mitral leaflets</td>
<td>EROA ≥0.20 cm² Regurgitant volume ≥30 ml Regurgitant fraction ≥50%</td>
<td>Regional wall motion abnormalities with reduced LV systolic function LV dilation and systolic dysfunction due to primary myocardial disease</td>
<td>HF symptoms due to MR persist even after revascularization and optimization of medical therapy Decreased exercise tolerance Exertional dyspnea</td>
</tr>
</tbody>
</table>

*Several valve hemodynamic criteria are provided for assessment of MR severity; 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. Adapted with permission from Nishimura et al. (19).

EROA = effective regurgitant orifice area; LV = left ventricular; MR = mitral regurgitation.
<table>
<thead>
<tr>
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<th>Primary (Organic) MR</th>
<th>Secondary (Functional) MR</th>
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<tbody>
<tr>
<td>EROA</td>
<td>≥0.4 cm²</td>
<td>≥0.2 cm²*</td>
</tr>
<tr>
<td>Regurgitant volume</td>
<td>≥60 ml</td>
<td>≥30 ml</td>
</tr>
<tr>
<td>Regurgitant fraction</td>
<td>≥50%</td>
<td>≥50%</td>
</tr>
<tr>
<td>Vena contracta</td>
<td>≥0.7 cm</td>
<td>–</td>
</tr>
<tr>
<td>Jet area</td>
<td>Central jet &gt;40% LA</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>or holosystolic eccentric jet</td>
<td>–</td>
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</tbody>
</table>

*Measurement of the proximal isovelocity surface area by 2-dimensional transthoracic echocardiography in secondary MR underestimates the true EROA due to the crescent shape of the proximal convergence. Adapted with permission from Nishimura et al. (19).
FMR

- In functional ischaemic MR, an EROA ≥20 mm² or an RVol ≥30 mL identifies a subset of patients at an increased risk of cardiovascular events
Loading Conditions Effect on MR Severity

- LV unloading may lessen regurgitation, quantification of MR severity is most accurately assessed in the awake patient by TTE
- Thereby avoiding the vasodilatory effects of sedation, hypovolemia, and/or anesthesia with TEE
Large V wave in severe MR pressure waveform.
FMR Hemodynamics

• Volume (not pressure) load to the LV
• Absolute volume of MR flow depends on:
  • Pressure gradient between LV and LA
  • Size of the MR orifice during systole (dynamic)
  • LV systolic ejection time (HR dependent)
• Parallel emptying of the LV into both the high pressure systemic circulation and the low pressure LA (reduced overall impedance)
The Importance of V Wave

• May be:
  • Antegrade from the PVs or
  • Retrograde from the LV
What is Large V Wave?

• Peak v wave >40 mmHg
• Difference between the peak v wave and mean PCWP >10 mmHg
• Ratio of the peak v wave to mPCWP >2
• v wave height 3xmPCWP
V Wave in Chronic MR

• Presence or absence of an abnormal v wave fails to correlate with either the presence or severity of chronic MR
• 1/3 of patients with prominent v waves had no MR
• Prominent v wave was insensitive and had a poor positive predictive value for the presence of moderate or severe MR
• Absence of a prominent v wave was 94% specific and had a 93% NPV for the absence of severe MR - This study consisted mostly of patients with chronic MR
V Wave Caveats in Chronic MR

• Gradient is present during early diastole only
• Slope of the $y$ descent in MR is steep
• Large $v$ waves are a prominent feature of both mitral stenosis and CHF
• Tachycardia may result in $v$ waves due to the shorter diastolic emptying period.
Why V Wave Height Not Reliable?

1. Rate & volume of blood that enter the LA during ventricular systole
2. Volume and pressure of blood that exist within the LA
3. Systemic afterload that influences atrial emptying
4. LV contractile force that affects both left ventricular end-diastolic volume and pressure
5. LA compliance
Hemodynamics Pre & Post MC

Pre-procedure
CO 2.2L/m

CO increase
mLAP/mPCW - may
decrease or remain
same
V wave decreases

Post-procedure
CO 4.5L/m
Summary

• MR is a volume problem
• FMR hemodynamics sensitive to loading conditions
• Became more common than primary MR
• LAP monitoring during percutaneous MV repair procedures
There are some questions that can't be answered by Google.