Mitral Stenosis

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Youssef Nasr, MD FACC
No conflict of interests
Agenda

- Etiology/Pathology
- Pathophysiology
- Physical exam
- Diagnosis: Echo, Stress Echo, Invasive
- Management

To answer questions:
PollEv.com/youssefnasr871
Text: YOUSSEFNASR871 to 22333
Etiology

- Rheumatic heart disease
  - 25% have isolated MS
  - 40% with mixed MS and MR
  - 38% with multi-valve involvement: 35% aortic valve, 6% tricuspid valve (rarely PV)
  - 2/3 patients are women
  - Only half can recall past hx RF - Time from RF and valve obstruction – few years to > 20y

Carapetis et al, Nat Rev Dis Primers 2016 Jan 14;2:15084. doi: 10.1038/nrdp.2015.84
Pathology: Rheumatic Heart disease

- Fusion of commissures = MS (fish mouth)
  - Restriction of leaflet motion, especially anterior leaflet = diastolic doming
- Thickening of valve leaflets
- Shortening and thickening of chordae
- Funnel shaped valve apparatus; marked obstruction to blood flow from LA to LV
Etiology

• Degenerative Mitral Stenosis; mitral annular calcification (MAC)
• Radiation induced
• Congenital; parachute, double orifice, sub-valvular stenosing ring
• Other acquired: carcinoid, myxoma, thrombus, endocarditis, ergotamine induced…
Mitral stenosis
obstruction to left atrial emptying

Difficulty in
LV filling

LA pressure
→ Change in LA function

Pulmonary venous pressure

Perivascular edema
luminal narrowing

Reversal of pulmonary blood flow

Pulmonary compliance
↓ Work of breathing

Pulmonary arterial pressure

Cardiac output

Severe pulmonary hypertension

Stable with mild symptoms

Pulmonary vascular resistance

Right ventricular overload

Tricuspid regurgitation
Physical Exam
Which of the following statements regarding mitral stenosis is FALSE?

A. The opening snap (OS) is an early diastolic sound
B. A long A2-OS interval implies severe mitral stenosis
C. In atrial fibrillation, the A2-OS interval varies with cycle length
D. The “snap” is generated by rapid reversal of the position of the anterior mitral leaflet
E. The presence of an opening snap implies a mobile body of the anterior mitral leaflet
Mitral Stenosis: Physical Exam

OS

- Diagnostic of MS: Heard when the movement of mitral doming into LV suddenly stops – sudden tensing of valve leaflets after the cups have completed their opening in early diastole
- Med to high frequency
- Intensity doesn’t correlate to severity of MS
- Severe MS = narrow A2-OS
- Best heard medial to LV apex, may be better in decubitus

S1

- Loud, snapping S1 is hallmark of MS
- Direct relationship b/w audibility and intensity of S1 and OS
- Loud when MV mobile enough
- When stiff, both quieter
- Loudest over apex and LLSB
- S1 disappears as disease progresses
Mitral Stenosis: Physical Exam

1. First heart sound (S1) is accentuated and snapping
2. Opening snap (OS) after aortic valve closure
3. Low pitch diastolic rumble at the apex
4. Pre-systolic accentuation (esp. if in sinus rhythm)
Echocardiography
Parasternal window
M-Mode

normal

thickened immobile leaflets

[Diagram showing normal and thickened immobile leaflets]
# Wilkins Score

## Abascal’s Score

### Assessment of mitral valve anatomy according to the Wilkins score[5]

<table>
<thead>
<tr>
<th>Grade</th>
<th>Mobility</th>
<th>Thickening</th>
<th>Calcification</th>
<th>Subvalvular Thickening</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Highly mobile valve with only leaflet tips restricted</td>
<td>Leaflets near normal in thickness (4-5 mm)</td>
<td>A single area of increased echo brightness</td>
<td>Minimal thickening just below the mitral leaflets</td>
</tr>
<tr>
<td>2</td>
<td>Leaflet mid and base portions have normal mobility</td>
<td>Midleaflets normal, considerable thickening of margins (5-8 mm)</td>
<td>Scattered areas of brightness confined to leaflet margins</td>
<td>Thickening of chordal structures extending to one-third of the chordal length</td>
</tr>
<tr>
<td>3</td>
<td>Valve continues to move forward in diastole, mainly from the base</td>
<td>Thickening extending through the entire leaflet (5-8mm)</td>
<td>Brightness extending into the mid-portions of the leaflets</td>
<td>Thickening extended to distal third of the chords</td>
</tr>
<tr>
<td>4</td>
<td>No or minimal forward movement of the leaflets in diastole</td>
<td>Considerable thickening of all leaflet tissue (&gt;8-10mm)</td>
<td>Extensive brightness throughout much of the leaflet tissue</td>
<td>Extensive thickening and shortening of all chordal structures extending down to the papillary muscles</td>
</tr>
</tbody>
</table>

- The total score is the sum of the four items and ranges between 4 and 16.
Quantification

• Mitral valve area
  • Planimetry
  • Pressure half time
  • Continuity equation
  • PISA

• Mean diastolic pressure gradient
Quantification: Planimetry

• The reference measurement of MVA:
  • It offers the best correlations with anatomic MV Area
  • It is less dependent on flow, heart rate, chamber compliance

• Not influenced by concomitant other valvulopathy (mitral regurgitation, aortic regurgitation, aortic stenosis, tricuspid regurgitation or stenosis)

• The most reliable tool to estimate MVA after PMC
Quantification: Planimetry
2D
Quantification: Planimetry 3D

During routine assessment of a patient with known valvular disease, the sonographer measures a mitral inflow deceleration time of 758 ms. Which of the following is a reasonable estimate of the mitral valve area?

A. 1 cm$^2$.
B. 0.3 cm$^2$.
C. 3 cm$^2$.
D. 1.5 cm$^2$.
E. 2 cm$^2$. 
Quantification: Pressure Half Time (HATLE)

Time interval (ms) between the maximum mitral gradient in early diastole and the time point where the gradient is half the maximum value.

\[ \text{PHT} = 0.29 \times \text{Deceleration Time (DT)} \]

\[ \text{MVA} = \frac{750}{\text{DT}} \]

Hatle L. Circulation 1979; 60: 1096-1104
Using trace 1 for measuring MVA half-time is a common mistake. The first part of the signal is reflective of both left atrial and ventricular pressure, not only mitral stenosis. Current ASE recommendations suggest the use of trace #2.
Quantification: Pressure Half Time Limitations

- Atrial fibrillation
- Unreliable Post valvuloplasty
- ASD; MVA is overestimated
- AI: MVA is overestimated
- Increased PHT is not always MS (can be abnormal relaxation; clue E velocity not increased. MG normal)
Limitations:
- Errors in measurements (LVOT diam, LVOT TVI, mitral TVI)
- Afib
- Associated MR or AR
  - MS overestimated if severe MR
  - MS underestimated if severe AR
Quantification: Proximal isovelocity surface area (PISA)

MVA = 6.28 x r^2 x \frac{V_r}{V_{max}} x \frac{\alpha}{180}
Quantification: Proximal isovelocity surface area (PISA)

Correlation between MVA assessed by the PISA method (MVA-PISA) using a fixed angle correction of 100° and by planimetry (MVA2D)

SOA = (6.28 r² x Va) x 100 /180 / VE
Quantification: Proximal isovelocity surface area (PISA)

Simplifying proximal isovelocity surface area as an assessment method of mitral valve area in patients with rheumatic mitral stenosis by fixing aliasing velocity and mitral valve angle

Alaa Mabrouk Salem Omar, Mohammed Ahmed Abdel-Rahman, Hidekazu Tanaka, Osama Rifaie

\[
PISA_{\text{simple}} = 2\pi r^2 \times \left( \frac{\text{Val}}{V_{\text{max}}} \right) \times \left( \frac{\alpha}{180} \right) \\
= 2 \times 3.14 \times r^2 \times \left( \frac{33}{V_{\text{max}}} \right) \times \left( \frac{100}{180} \right) \\
= (2 \times 3.14 \times 33 \times 100/180) \times \left( \frac{r^2}{V_{\text{max}}} \right) \\
= 115 \times \frac{r^2}{V_{\text{max}}}
\]

MVA = 115 \times 1 / 188 = 0.61 \text{ cm}^2
Quantification: Mean Pressure Gradient

- The mean pressure gradient is highly dependent on the transvalvular flow and diastolic filling period and will vary greatly with changes in heart rate.

- Report HR in which gradients were obtained and average 5 cardiac cycles in case of Afib
# Quantification

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Units</th>
<th>Formula / Method</th>
<th>Concept</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve area</td>
<td></td>
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</tr>
<tr>
<td>- planimetry by 2D echo</td>
<td>cm²</td>
<td>tracing mitral orifice using 2D echo</td>
<td>direct measurement of anatomic MVA</td>
<td>- accuracy</td>
<td>- experience required</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- independence from other factors</td>
<td>- not always feasible (poor acoustic window, severe valve calcification)</td>
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<tr>
<td></td>
<td></td>
<td>cm²</td>
<td>rate of decrease of transmirtal flow is inversely proportional to MVA</td>
<td>easy to obtain</td>
<td>dependence on other factors (AR, LA compliance, LV diastolic function...)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>220 / T₁/2</td>
<td></td>
<td></td>
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<tr>
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<td></td>
</tr>
<tr>
<td>continuity equation</td>
<td>cm²</td>
<td>MVA = (CSA_{LVOT}) (VTI_{Aortic}) / VTI_{Mitra}</td>
<td>volume flows through mitral and aortic orifices are equal</td>
<td>independence from flow conditions</td>
<td>- multiple measurements (sources of errors)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>- not valid if significant AR or MR</td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>PISA</td>
<td>cm²</td>
<td>MVA = (\pi(r^2)(V_{\text{clashing}})) / peak (V_{\text{Mitra}}) (\alpha/180^\circ)</td>
<td>MVA assessed by dividing mitral volume flow by the maximum velocity of diastolic mitral flow</td>
<td>independence from flow conditions</td>
<td>technically difficult</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean gradient</td>
<td>mm Hg</td>
<td>(\Delta P = \Sigma 4v^2 / N)</td>
<td>pressure gradient calculated from velocity using the Bernoulli equation</td>
<td>easy to obtain</td>
<td>dependent on heart rate and flow conditions</td>
</tr>
<tr>
<td>Systolic pulmonary artery pressure</td>
<td>mm Hg</td>
<td>sPAP = 4v²_{Tricuspid} + RA pressure</td>
<td>addition of RA pressure and maximum gradient between RV and RA</td>
<td>obtained in most patients with MS</td>
<td>- arbitrary estimation of RA pressure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- no estimation of pulmonary vascular resistance</td>
</tr>
</tbody>
</table>
| Mean gradient and systolic pulmonary artery pressure at exercise | mm Hg | \(\Delta P = \Sigma 4v^2 / N\) 
\(sPAP = 4v^2_{Tricuspid} + RA pressure\) | assessment of gradient and sPAP for increasing workload | incremental value in assessment of tolerance | - experience required |
|            |       |                  |         |            | - lack of validation for decision-making |
| Valve resistance | dyne·sec⁻¹·cm⁻⁵ | \(\text{Mvres} = \frac{P_{\text{Mitra}}}{(\text{CSA}_{LVOT})(\text{VTI}_{Aortic}) / \text{DFT}}\) | resistance to flow caused by MS | initially suggested to be less flow-dependent, but not confirmed | no prognostic value |
|            |       |                  |         |            | no clear threshold for severity |
|            |       |                  |         |            | no additional value vs. valve area |

### 2014 AHA/ACC Guidelines

<table>
<thead>
<tr>
<th>Stage</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 MS</td>
<td>Mild valve doming during diastole</td>
<td>Normal transmitral flow velocity</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>B</td>
<td>Progressive MS</td>
<td>Rheumatic valve changes with commissural fusion and diastolic doming of the mitral valve leaflets</td>
<td>Increased transmitral flow velocities</td>
<td>Mild-to-moderate LA enlargement</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Planimetered MVA &gt;1.5 cm²</td>
<td>MVA &gt;1.5 cm²</td>
<td>Normal pulmonary pressure at rest</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Asymptomatic severe MS</td>
<td>Rheumatic valve changes with commissural fusion and diastolic doming of the mitral valve leaflets</td>
<td>MVA ≤1.5 cm² (MVA ≤1.0 cm² with very severe MS)</td>
<td>Severe LA enlargement</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Planimetered MVA ≤1.5 cm² (MVA ≤1.0 cm² with very severe MS)</td>
<td>Diastolic pressure half-time ≥150 ms</td>
<td>Elevated PASP &gt;30 mm Hg</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Symptomatic severe MS</td>
<td>Rheumatic valve changes with commissural fusion and diastolic doming of the mitral valve leaflets</td>
<td>MVA ≤1.5 cm² (MVA ≤1.0 cm² with very severe MS)</td>
<td>Severe LA enlargement</td>
<td>Decreased exercise tolerance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Planimetered MVA ≤1.5 cm²</td>
<td>Diastolic pressure half-time ≥150 ms</td>
<td>Elevated PASP &gt;30 mm Hg</td>
<td>Exertional dyspnea</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Diastolic pressure half-time ≥220 ms with very severe MS)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
AHA/ACC guideline for the management of patients with valvular heart disease. Circulation 2014

Exercise testing with Doppler or invasive hemodynamic assessment is recommended to evaluate the response of the mean mitral gradient and pulmonary artery pressure in patients with MS when there is a discrepancy between resting Doppler echocardiographic findings and clinical symptoms or signs. (Class I, Level of Evidence: C)


Stress testing is indicated in patients with no symptoms or symptoms equivocal or discordant with the severity of MS. Dobutamine or, preferably, exercise echocardiography may provide additional information by assessing changes in mitral gradient and pulmonary pressures.
Stress Echo

-Semi-supine echocardiography exercise is now preferred to post exercise echo
-Allows monitoring gradient and PA pressure in each step of increasing workload
Stress Echo

Interpretation:

• Exercise capacity- symptoms?
• Mean trans-mitral gradient > 15 mmHg (or 18 mmHg dobutamine)
• Progression of SPAP (>60 mmHg)

Need of multicentric studies with long follow up:
prognostic value / strongest position in the guidelines
MVA = cardiac output ÷ [37.7 x DFP x heart rate x sq rt mean gradient]
A 78-year-old woman has been complaining of worsening dyspnea on exertion for the past 6 months. She has a hypertension that is poorly controlled despite treatment with a diuretic, ACEI and CCB. Her PCP noted a murmur and requested an echocardiogram. This shows presence of a mildly enlarged left ventricle, with calculated ejection fraction of 65%. The aortic valve is sclerotic, with a MG of 10 mm Hg and moderate regurgitation. The mitral annulus and base of mitral valve leaflets are densely calcified, with a mean diastolic gradient of 9 mm Hg at a heart rate of 82 beats/min. The E velocity is 2.1 m/s, with a pressure half-time of 110 ms. The mitral valve area by planimetry in short-axis parasternal view is 1.3 cm². Which of the following statements is correct.

A. The mitral valve area is best estimated in this patient by the pressure half-time method.
B. Mitral balloon valvuloplasty is indicated in this symptomatic patient.
C. Mitral valve replacement is indicated in this symptomatic patient.
D. Mitral stenosis severity should be reassessed after blood pressure and heart rate are better controlled.
Management
<table>
<thead>
<tr>
<th>Recommendations</th>
<th>COR</th>
<th>LOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMBC is recommended for symptomatic patients with severe MS (MVA ≤ 1.5 cm², stage D) and favorable valve morphology in the absence of contraindications</td>
<td>I</td>
<td>A</td>
</tr>
<tr>
<td>Mitral valve surgery is indicated in severely symptomatic patients (NYHA class III/IV) with severe MS (MVA ≤ 1.5 cm², stage D) who are not high risk for surgery and who are not candidates for or failed previous PMBC</td>
<td>I</td>
<td>B</td>
</tr>
<tr>
<td>Concomitant mitral valve surgery is indicated for patients with severe MS (MVA ≤ 1.5 cm², stage C or D) undergoing other cardiac surgery</td>
<td>I</td>
<td>C</td>
</tr>
<tr>
<td>PMBC is reasonable for asymptomatic patients with very severe MS (MVA ≤ 1.0 cm², stage C) and favorable valve morphology in the absence of contraindications</td>
<td>IIa</td>
<td>C</td>
</tr>
<tr>
<td>Mitral valve surgery is reasonable for severely symptomatic patients (NYHA class III/IV) with severe MS (MVA ≤ 1.5 cm², stage D), provided there are other operative indications</td>
<td>IIa</td>
<td>C</td>
</tr>
<tr>
<td>PMBC may be considered for asymptomatic patients with severe MS (MVA ≤ 1.5 cm², stage C) and favorable valve morphology who have new onset of AF in the absence of contraindications</td>
<td>IIb</td>
<td>C</td>
</tr>
<tr>
<td>PMBC may be considered for symptomatic patients with MVA &gt; 1.5 cm² if there is evidence of hemodynamically significant MS during exercise</td>
<td>IIb</td>
<td>C</td>
</tr>
<tr>
<td>PMBC may be considered for severely symptomatic patients (NYHA class III/IV) with severe MS (MVA ≤ 1.5 cm², stage D) who have suboptimal valve anatomy and are not candidates for surgery or at high risk for surgery</td>
<td>IIb</td>
<td>C</td>
</tr>
<tr>
<td>Concomitant mitral valve surgery may be considered for patients with moderate MS (MVA 1.6–2.0 cm²) undergoing other cardiac surgery</td>
<td>IIb</td>
<td>C</td>
</tr>
<tr>
<td>Mitral valve surgery and excision of the left atrial appendage may be considered for patients with severe MS (MVA ≤ 1.5 cm², stages C and D) who have had recurrent embolic events while receiving adequate anticoagulation</td>
<td>IIb</td>
<td>C</td>
</tr>
</tbody>
</table>
Contraindications to percutaneous mitral commissurotomy

- Mitral valve area >1.5 cm²
- Left atrial thrombus
- More than mild mitral regurgitation
- Severe or bicommissural calcification
- Absence of commissural fusion
- Severe concomitant aortic valve disease, or severe combined tricuspid stenosis and regurgitation
- Concomitant coronary artery disease requiring bypass surgery
Thank you

ynasr@mcclinic.com