Mitral Stenosis
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Mitral Valve Anatomy

The mitral valve is composed of two leaflets—the anterior mitral leaflet (AML) and the posterior mitral leaflet (PML). The anterior mitral leaflet is larger than the posterior leaflet, but attaches to only 1/3 of the mitral annulus. The posterior mitral leaflet is smaller but attaches to 2/3 of the annulus. The posterior leaflet is scalloped into three distinct sections—the anterior lateral scallop or P1, the middle scallop or P2 and the posteriomedial scallop or P3. The anterior leaflet is not anatomically divided into distinct segments, but we refer to A1, A2 and A3 as the corresponding segments (not scallops) to the posterior leaflet. Inspection of the mitral valve should always include the entire apparatus: the leaflets, the annulus, and the subvalvular structures (cordae and papillary muscles).

Mitral Stenosis

Rheumatic Fever is the most common cause of mitral stenosis. Other less common etiologies include: mitral annular calcification, endocarditis, congenital lesions, SLE and carcinoid syndrome. Mitral valve repair also frequently results in a stenotic valve. The mitral valve should therefore be inspected following repair to rule out significant obstruction.

<table>
<thead>
<tr>
<th>MVA</th>
<th></th>
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<tbody>
<tr>
<td>Normal</td>
<td>4-6 cm²</td>
</tr>
<tr>
<td>Mild Stenosis</td>
<td>1.6-2.0 cm²</td>
</tr>
<tr>
<td>Moderate Stenosis</td>
<td>1.1-1.5 cm²</td>
</tr>
<tr>
<td>Severe Stenosis</td>
<td>&lt; 1.0 cm²</td>
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</table>

2D exam

Initial evaluation of the mitral valve should begin with 2D inspection of the leaflets. Rheumatic mitral stenosis is characterized by thickened, calcified leaflets with obstruction of inflow into the left ventricle. In Rheumatic Heart Disease, the thickening begins at the leaflet tips and extends down the commissures toward the remaining portions of the leaflets. Since leaflet motion is restricted mostly at the leaflet tips, the leaflets have a characteristic doming appearance in diastole (hockey stick deformity). The posterior leaflet is often times immobile. The entire mitral valvular apparatus is involved in this pathologic process as the chordae become thickened, shortened, and often fused—therefore contributing to the restricted leaflet movement.

![Anterior leaflet. Hockey stick deformity](image)

Figure 1: Long Axis View of the Left Ventricle: The anterior leaflet appears thickened and displays diastolic doming or a hockey-stick deformity which is characteristic of RHD

Pressure Gradients
Elevation of the mean pressure gradient is the hallmark of mitral stenosis. To determine, obtain the maximal velocity using continuous wave Doppler from the mid-esophageal images. Trace the entire mitral valve spectral profile and the computer software will integrate the velocities and calculate the mean gradient.

![CW profile of the MV inflow. Tracing over the entire spectral profile will yield a mean mitral pressure gradient from the machine software](image)

**Mean Gradient:**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Gradient</th>
</tr>
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<tbody>
<tr>
<td>Mild</td>
<td>&lt; 5 mm Hg</td>
</tr>
<tr>
<td>Moderate</td>
<td>5-12 mm Hg</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt; 12 mm Hg</td>
</tr>
</tbody>
</table>

**Calculation of MVA**

There are several methods available to determine MVA, each with advantages and disadvantages. It is best to use several techniques for confirmation of disease and severity.

**Planimetry**

Mitral valve area can be measured by planimetry in the transgastric basal short axis view. The image of the mitral valve is frozen in diastole and the opening is traced. Since the mitral valve is not flat (it forms a funnel shape) the imaging plane should be moved back and forth in order to determine the narrowest part of the valve. This will be the limiting aspect of the ventricular inflow.

![Planimetry of the mitral valve is performed in the basal short axis view. The narrowest portion of the valve should be traced.](image)

**Planimetry Limitations:**

Extensive calcifications can make determination of the exact location of the mitral valve edge difficult. Patients with previous commissurotomies are also technically challenging. Caution not to over-gain as this can lead to error.
**Pressure Half Time:**

PHT uses the rate of pressure drop across the mitral valve as a measure of mitral severity. As the severity of the mitral stenosis increases, the time it takes the pressure between the left atrium and left ventricle to equalize during diastole increases. Pressure half time is the time it takes for the peak transmitral pressure gradient to decrease by half. When the mitral valve area is 1.0 cm² it takes 220 ms for the pressure gradient across the mitral valve to drop to half its original value. Therefore, 220 divided by the pressure half time will give the mitral valve area in cm².

\[ \text{MVA} = \frac{220}{\text{PHT}} \]

Not all increased PHT’s indicate mitral stenosis. Patients with abnormal myocardial relaxation have a prolonged PHT, but the peak E velocity is not increased and is usually lower than 1 m/sec. In patients with atrial fibrillation, several cycles should be averaged. Occasionally, there are two separate slopes of mitral velocity - a more peaked initial slope and a second slope with a longer duration. The PHT should be measured from the latter. At faster heart rates, the E wave and the A wave begin to fuse and it may be difficult to distinguish the slope of the velocity profile. This may be overcome by decreasing the sweep speed of the spectral profile.

**To measure Pressure Half Time:**

1. Optimize CW mitral inflow velocity
2. Change sweep speed to 100mm/s
3. Trace the slope of the E wave
4. The machine software package will provide you with PHT and MVA

Older machines may not have a software package to calculate PHT-- it can be done manually:

1. Optimize CW mitral inflow velocity
2. Change sweep speed to 100mm/s
3. Measure the peak E wave velocity, or \( V_{\text{MAX}} \)
4. \( V_{\text{MAX}} + 1.4 = V_{1/2} \)
5. Draw vertical lines from E slope to baseline at \( V_{\text{MAX}} \) and \( V_{1/2} \)
6. Measure time interval (\( T_{1/2} \)) from \( V_{\text{MAX}} \) to \( V_{1/2} \)
7. \( \text{MVA} = \frac{220}{T_{1/2}} \)

**Deceleration Time**

Alternatively, Deceleration time can be used to calculate MVA. Pressure half time is 0.29% of deceleration time. Therefore

\[ \text{MVA} = \frac{760}{\text{DT}} \]

\[ \text{PHT} = 0.29 \times \text{DT} \]
PHT/Deceleration Time Limitations:

Aortic Insufficiency and abnormal myocardial relaxation will underestimate the severity of MS by PHT. PHT has not been validated in the post CPB patients and has been found inaccurate in post-commissurotomy patients due to its dependence on net chamber compliance.

**Continuity Equation**
The continuity equation and the conservation of energy states:

\[
\text{LVOT (area)} \times \text{LVOT (TVI)} = \text{MV (area)} \times \text{MV (TVI)}
\]

- **LVOT area** = left ventricular outflow tract area
- **LVOT (TVI)** = left ventricular outflow tract time-velocity integral
- **MV (TVI)** = mitral valve time-velocity integral

Mitral Valve area can therefore be determined with the three of the other variables in the equation. LVOT area is determined by calculation of \( \pi r^2 \) (the formula for area of a circle), where \( r \) is the \( \frac{1}{2} \) the diameter of the LVOT measured in the aortic LAX view and the respective TVI’s are obtained using spectral Doppler. LVOT TVI can be obtained with PWD in the deep transgastric position and the TVI of the MV obtained in the mid-esophageal position using CWD.

![Figure 5: Continuity equation demonstrated](image)

**Associated Findings**
The increased left atrial pressure associated with mitral stenosis leads to **left atrial enlargement**, **pulmonary hypertension**, **right ventricular enlargement** and **tricuspid regurgitation**. Left atrial size should be measured in the short axis view of the aortic valve, as this view has best been correlated with transthoracic images. Left atrial dilation with low flow and high pressure can lead to thrombus formation and the left atrium and appendage should be inspected thoroughly before and after surgery. **Regional wall motion abnormalities** of the posterior-basal myocardium in patients without CAD occur with severe rheumatic mitral stenosis and may indicated a mechanical tethering of the myocardium caused by a scarred mitral valve. All of these secondary findings can help confirm the diagnosis of mitral stenosis and aid in the determination of severity.
LA > 39 mm indicative of LAE
Interatrial septum bowing to the right indicative of increased LAP

Left atrial size should be measured in the short axis view of the AV

Mitral Stenosis Severity

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<th></th>
<th>MILD</th>
<th>Moderate</th>
<th>Severe</th>
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<tr>
<td>Mean gradient (mmHg)</td>
<td>6</td>
<td>6-12</td>
<td>&gt;12</td>
</tr>
<tr>
<td>PHT (msec)</td>
<td>100-150</td>
<td>150-200</td>
<td>&gt;220</td>
</tr>
<tr>
<td>MVA (cm²)</td>
<td>1.5-2.0</td>
<td>1.0-1.5</td>
<td>&lt;1.0</td>
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References

1. Bruce C., Nishimura R. Valvular Heart Disease CLINICAL ASSESSMENT AND MANAGEMENT OF MITRAL STENOSIS. Cardiology Clinics. Volume 16 • Number 3 • August 1998
2. Aronow W. Usefulness of M-Mode, 2-Dimensional, and Doppler Echocardiography in the Diagnosis, Prognosis, and Management of Valvular Aortic Stenosis, Aortic Regurgitation, and Mitral Annular Calcium in Older Patients * Journal of the American Geriatrics Society Volume 43 • Number 3 • March 1995