Echocardiographic evaluation of mitral stenosis

Euroecho 2011

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DECLARATION OF INTEREST:

✓ I have nothing to declare
The Use of Ultrasonic Reflectoscope for the Continuous Recording of the Movements of Heart Walls.

By

I. Edler and C. H. Hertz.

Communicated by Prof. B. Edsén, March 10, 1954.

Fig. 10. UCG-curve showing the movements of left auricular wall in a case of mitral stenosis. Top: The curve shows a reflecting surface about almost 6 cm. from the anterior thoracic wall in the beginning of diastole. Bottom: Enlargement of the reflecting surface. From the beginning of ventricular diastole, when the atrio-ventricular valves open, the reflecting surface moves 6-7 mm. in dorsal direction. Immediately after the beginning of the P-wave in the electrocardiogram the sound reflecting surface makes a rapid movement in dorsal direction. This movement has an amplitude of about 2 cm.

During ventricular systole the wall returns to its original position.

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EuroHeart Survey
Etiology of single native left-sided valve disease

Eur Heart J 2003 Jul;24(13):1231-43
Typical M-mode and 2D echocardiographic features of rheumatic MS
Degenerative MS
Echocardiographic differential diagnosis of LV inflow obstruction

LV diastolic dysfunction

- Rheumatic
- Degenerative/Calcific
- Congenital
- Carcinoid heart disease
- SLE
- Rheumatoid arthritis
- Hunter-Hurler
- Fabry disease
- Whipple disease
- Methysergide therapy

Cor triatriatum

Myxoma

Thrombus
Echocardiographic evaluation of the patient with MS

- MS severity
  - Pressure gradient
  - Valve area
  - Exercise

- Presence and severity of coexisting MR

- Mitral valve anatomy

- LA thrombus? (before PBV)

- LA, LV, RV size and function

- Pulmonary systolic pressures

- (Rheumatic) involvement of other valves?
Pressure gradient: simplified Bernoulli equation
\[ \Delta P = 4v^2 \]

Mean gradient 18 mm Hg

Nishimura RA et al. J Am Coll Cardiol 1994;24:
Pitfalls in evaluation of MS severity
Pressure gradient

- Intercept angle between MS jet and ultrasound beam
- Beat-to-beat variability in AF
- Dependence
  - on transvalvular volume flow rate and
  - on diastolic filling period
  - exercise, infection, pregnancy, coexisting MR
Relation between pressure gradient and mitral valve area: Role of transmitral diastolic flow rate

![Graph showing the relationship between gradient and flow with different valve areas indicating increasing severity.]

- Gradient
- Flow
- 2.0 cm²
- 1.5 cm²
- 1.0 cm²
- Increasing severity
Planimetry

Reference method

Pitfalls: Image orientation and tomographic plane

MVA 1.1 cm²

MVA 1.5 cm²
Pitfalls: 2D gain settings

1.05 cm²

0.72 cm²
Pitfalls
Poor acoustic access, severe distortion of valve anatomy, severe calcium++ on leaflet tips

Feasibility in the elderly?


\[ r = 0.39 \]
Pressure half-time method

Moderate MS

Severe MS

LV

LA
Pressure half-time method

MVA = 220/PHT

Hatle et al. Circulation 1979
Accuracy of Doppler PHT method in assessing severity of MS in patients with and without prior commissurotomy

Unoperated patients (N=37)

Previous commissurotomy (11.2±5.4 yrs before) (N=37)

Pitfalls in PHT-derived valve area calculation

- Coexisting moderate-to-severe AR
- Immediately after commissurotomy
- In the elderly (AHT, associated AS)

LV compliance/relaxation/pressure

MS severity

LA compliance
Atrial Fibrillation

Pitfalls of PHT method

Curvilinear slope

Atrial Fibrillation
Pitfalls of PHT method

E/A fusion

Carotid Sinus Massage

HR 85 bpm
Mean gradient 17 mm Hg

HR 73 bpm
Mean gradient 10 mm Hg
Pitfalls of PHT method

Lutembacher syndrome
MS+ASD
Proximal Isovelocity Surface Area (PISA) Method

\[ MVA = 2\pi (r^2)(V_{\text{aliasing}})/\text{Peak } V_{\text{mitral}} \]
1. Zoom on the flow convergence
2. Aliasing velocity 20-30 cm/s
3. Measure the radius of the flow convergence and the transmitral velocity
4. Measure the angle formed by the mitral leaflets

\[ MVA = \left(2\pi r^2\right) \times \frac{\text{aliasV}}{\text{maxV}} \times \frac{\theta}{180} \]

\[ \theta = 90^\circ \]

\[ \theta = 180^\circ \]
4. Measure the angle formed by the mitral leaflets

\[ \text{MVA} = (2\pi r^2) \times \frac{\text{aliasV}}{\text{maxV}} \times \frac{\theta}{180} \]

\[ \theta = 100^\circ \]
5. Apply the formula

\[ MV_A = R^2 \cdot 2\pi \cdot \text{alias} \frac{V}{V_{\text{max}}} \cdot \frac{\theta}{180^\circ} \]

\[ MVA = (1.71)^2 \cdot 6.28 \cdot 25 / 252 \cdot 10/180 = 1.01 \text{ cm}^2 \]
MVA assessed by the PISA method using a fixed correction angle of 100° versus MVA measured by the PISA method with the exact angle measured using a protractor.

\[
MVA = (2\pi r^2) \times \text{alias}V / \text{max}V \times \frac{100}{180}
\]

MVA assessed by the PISA method using a fixed angle correction of 100° versus planimetry

MVA = \((2\pi r^2) \times \text{aliasV} / \text{maxV} \times \frac{100}{180}\)

The continuity equation

Mitral stroke volume = Aortic stroke volume

Mitral valve area \times Mitral TVI = LVOT diameter \times LVOT TVI
Continuity equation: Caveats

- Inaccuracy of LVOT diameter determination ($\pi r^2$)
- Caution if AF, as mitral and aortic stroke volumes are calculated from different beats
- Invalidated by aortic or mitral regurgitation
Underestimates severity

Overestimates severity

AR

MR

MVA = \frac{LVOT TVI}{LVOT diameter} \times Mitral TVI
Diagnostic caveats in patients with multivalve lesions

<table>
<thead>
<tr>
<th>Impacts on the diagnosis of:</th>
<th>AS</th>
<th>AR</th>
<th>MR</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AS</strong></td>
<td>NA</td>
<td>Prolonged PHT if left ventricular hypertrophy with impaired relaxation</td>
<td>High intraventricular pressure may result in higher RV whereas ERO is less affected</td>
<td>Low-flow low-gradient MS. Prolonged PHT if impaired left ventricular relaxation</td>
</tr>
<tr>
<td><strong>AR</strong> Gorlin formula using thermodilution technique invalid. Owing to high transaortic volume flow rate, maximum velocity, and pressure gradients may be higher than expected for a given valve area</td>
<td>NA</td>
<td>Not significantly affected</td>
<td>Not significantly affected</td>
<td>Owing to increased anterograde aortic flow, there is an overestimation of MVA by the continuity equation. Overestimation of MVA with PHT method. This approach is not valid.</td>
</tr>
<tr>
<td><strong>MR</strong> MR could favour a low-flow, low-gradient state. Aortic valve area calculation remains accurate. High-velocity MR jet may be mistaken for the AS jet (MR is longer in duration)</td>
<td>Not significantly affected</td>
<td>NA</td>
<td>Owing to increased anterograde mitral flow, there is an underestimation of MVA by the continuity equation. MVA may be underestimated with PHT method</td>
<td>Not significantly affected</td>
</tr>
<tr>
<td><strong>MS</strong> Low-flow low-gradient state. Aortic valve area calculation remains accurate</td>
<td>Blunted hyperdynamic circulation</td>
<td>Not significantly affected</td>
<td>NA</td>
<td>Gorlin formula invalid</td>
</tr>
</tbody>
</table>
| **TR** Gorlin formula invalid | Not affected | Not affected | Gorlin formula invalid |}

AR, aortic regurgitation; AS, aortic stenosis; ERO, effective regurgitant orifice; MR, mitral regurgitation; MS, mitral stenosis; MVA, mitral valve area; PHT, pressure half-time; RV, regurgitant volume; NA, not applicable.

Unger P et al. Heart 2011;97:272-277
70 y-o woman
Severe HF

LVOT VTI 21.2 cm
LVOT diam 1.7 cm

SV 48 ml
SVI 30 ml/m²
Max V 3.60 m/s
Mean PG: 32 mm Hg
Ao VTI: 96 cm
AVA: 0.5 cm²

Catheterization: AVA 0.6 cm²

Low flow low gradient AS
Mean PG: 8 mm Hg
Mi VTI: 52 cm
PHT: 90 ms
MVA (PHT): 2.4 cm²
MVA (continuity): 0.92 cm²

Catheterization: MVA 1.04 cm²

R=1.1 cm (alias 31 cm)
Max V 2.1 m/s
MVA (PISA) 1.12 cm²

Low flow low gradient MS
Low flow low gradient MS

Low flow low gradient AS
EAE/ASE RECOMMENDATIONS

Echocardiographic assessment of valve stenosis: EAE/ASE recommendations for clinical practice

- Pressure gradient
- Planimetry (2D)
- PHT

Level 1 EAE/ASE Recommendation

...appropriate and recommended for all patients...

- Continuity equation
- PISA

Level 2 EAE/ASE Recommendation

...reasonable when additional informations are needed in selected patients...
What about 3D echocardiography?
Real-time 3D color-defined planimetry using TTE in calcific MS

N = 34
mean age 72 ± 13 years

Real-time 3D transthoracic echocardiography

Real-time 3D transesophageal echocardiography
Real-time 3D TEE
3D-TEE Planimetry
MV leaflet tips using the short-axis view determined after multiplanar reconstruction

3D TEE versus other techniques

Feasibility

Mean difference vs other techniques (cm²)

P< 0.005  P< 0.0001  P= 0.82

Intraclass correlation coefficient interobs 0.93; intraobs 0.96

N=43

Correlation between MVA measured using 2D-TTE and real-time 3D-TEE measured by an experienced operator (upper panel) and by a non-experienced operator (lower panel)
Role of TEE?

• When acoustic windows are poor using TTE

• Percutaneous mitral commissurotomy
  – To exclude LA or LAA thrombus
  – Occasionally performed during MBV to guide transseptal puncture or position of a balloon.
Conclusions

• Evaluation of MS should determine
  – Its severity
  – Its suitability for PMC

• Strengths, pitfalls and limitations of each method of severity assessment should be known

• The decision-making process should also include
  – Associated valve lesions
  – Pulmonary pressure
  – Age
  – Heart rhythm
  – NYHA class
  – Predicted operative mortality
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Thank you for your attention!
### Recommendations for classification of MS severity

<table>
<thead>
<tr>
<th>Specific findings</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve area (cm²)</td>
<td>&gt;1.5</td>
<td>1.0-1.5</td>
<td>&lt;1.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supportive findings</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean gradient (mm Hg)*</td>
<td>&lt;5</td>
<td>5-10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Pulmonary artery pressure (mm Hg)</td>
<td>&lt;30</td>
<td>30-50</td>
<td>&gt;50</td>
</tr>
</tbody>
</table>

*At heart rate 60-80 bpm and in sinus rhythm


< 1 cm²/m²

## The echo examination in MS: ACC/AHA guidelines 2006

<table>
<thead>
<tr>
<th>Hemodynamic severity</th>
<th>Pressure gradient MVA PAP</th>
<th>TTE (TEE)</th>
<th>Class I, Level B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve morphology</td>
<td>Suitability for PMBV</td>
<td>TTE</td>
<td>Class I, Level B</td>
</tr>
<tr>
<td>If discrepancy between resting Doppler echo, clinical findings, symptoms and signs</td>
<td>Mean gradient MVA</td>
<td>Exercise TTE</td>
<td>Class I, Level C</td>
</tr>
<tr>
<td>LA thrombus</td>
<td>Suitability for PMBV</td>
<td>TEE</td>
<td>Class I, Level C</td>
</tr>
<tr>
<td>Co-existing MR</td>
<td>Evaluation of severity</td>
<td>TTE (TEE)</td>
<td>Class I, Level C</td>
</tr>
<tr>
<td>Routine evaluation of MV morphology and hemodynamics when TTE satisfactory</td>
<td></td>
<td>TEE</td>
<td>Class III</td>
</tr>
</tbody>
</table>
Images Displaying Different Views of the MV Commissure Using 3DTEE

(A) RT3D view of a rheumatic mitral valve.