Aortic Stenosis
Bicuspid Aortic Valve
Dilated Aortic Root

Amr E Abbas, MD, FACC, FSCAI, FASE, FSVM
Director, Interventional Cardiology Research
Co-Director, Echocardiography
Beaumont Health
Associate Professor of Medicine,
OU/WB School of Medicine

03/10/2005
Pre Questions (1)

• The Difference between Doppler MIG and catheterization PPG
  A. Is due to pressure recovery
  B. Is due to different measurement timing of the LV and aortic pressures
  C. Occurs only in patients with small aortas
  D. Is used to calculate aortic valve area
### Pre Questions (2)

- **The Difference between Doppler MIG and catheterization PPG**
  - A. Is due to pressure recovery
  - B. Is due to difference in the timing of the aortic pressure measurement between cath and echo
  - C. Is due to difference in the timing of the LV pressure measurement between cath and echo
  - D. Is related to the severity of aortic stenosis

### Pre Questions (3)

- **Catheter-Doppler Discordance maybe due to**
  - A. Pressure recovery
  - B. Eccentric jet
  - C. Very severe aortic stenosis
  - D. HOCM
Pre Questions (4)

• The most common form of bicuspid aortic valve is
  A. Fusion of the LCC/RCC
  B. Fusion of the LCC/NCC
  C. Fusion of the RCC/NCC
  D. Equal distribution of cusp fusion

<table>
<thead>
<tr>
<th>Severe Aortic Stenosis</th>
<th>Area Gradient Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Gradient (mmHg)</td>
<td>Valve Area (cm²)</td>
</tr>
<tr>
<td>Mild</td>
<td>&lt;25</td>
</tr>
<tr>
<td>Moderate</td>
<td>25- 40</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt;40</td>
</tr>
</tbody>
</table>

### Severe Aortic Stenosis

**Area Gradient Mismatch**

<table>
<thead>
<tr>
<th>Severity</th>
<th>Mean Gradient (mmHg)</th>
<th>Valve Area (cm²)</th>
<th>Valve Velocity (m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>&lt;20</td>
<td>&gt;1.5</td>
<td>2 - 2.9</td>
</tr>
<tr>
<td>Moderate</td>
<td>20-39</td>
<td>1.0-1.5</td>
<td>3 - 3.9</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt;40</td>
<td>&lt;1.0</td>
<td>&gt; 4.0</td>
</tr>
</tbody>
</table>

Nishimura, et al., Circulation, 2014

**Reverse Area Gradient Mismatch**

<table>
<thead>
<tr>
<th>Severity</th>
<th>Mean Gradient (mmHg)</th>
<th>Valve Area (cm²)</th>
<th>Valve Velocity (cm/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>&lt;20</td>
<td>&gt;1.5</td>
<td>2 – 2.9</td>
</tr>
<tr>
<td>Moderate</td>
<td>20-39</td>
<td>1.0-1.5</td>
<td>3 – 3.9</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt;40</td>
<td>&lt; 1.0</td>
<td>&gt; 4.0</td>
</tr>
</tbody>
</table>

Nishimura, et al., Circulation 2014

Aortic Stenosis
Determining the “True” Severity

Measurement Errors Must be Excluded

Topics of Discussions

• GOA Vs. EOA
• Doppler Vs. Catheter
• Factors affecting Gradient
• Area/Gradient Mismatch
• Reverse Area Gradient Mismatch
Evangelista Torricelli 1608-1647

Georg Simon Ohm 1789-1854
**Aortic Stenosis**

Catheterization: Flow $Q = \Delta \text{Pressure} \uparrow$

Doppler: Flow $Q = \text{Area} \times \text{Velocity}$

**Daniel Bernoulli**

1700-1782
Bernoulli Equation

\[ P_1 - P_2 = \frac{1}{2} \rho (V_2^2 - V_1^2) \]

Convective acceleration

\[ \rho \int_{\text{max}} (dv/dt) \times ds \]

Flow acceleration

Viscous Friction

P1&V1 = proximal to obstruction
P2&V2 = distal to obstruction
\( \rho \) = mass density of blood
R = viscous resistance
\( \mu \) = viscosity

Pressure Recovery

Pressure Energy In Ventricle

Doppler Gradient: \( \Delta P_{\text{max}} \)

Doppler/Catheter Concordance

Catheter Gradient: \( \Delta P_{\text{net}} \)
GOA Versus EOA

GOA: Planimetry
EOA: Continuity Equation
Coefficient of Contraction: EOA/GOA

Doppler versus Catheter Area and Gradient Assessment
Area Recovery

• Difference between Doppler and Catheter Effective Orifice Area
• 50% of EOA < 1 cm² with Doppler was > 1 cm² by Catheter

Upcoming Concepts

• For a given AV GOA
  The Gradient can be variable
  The EOA can be variable
  (Derived from gradient)
  The Area and Gradient may not match
  The Doppler and Catheter measures may not match
Doppler Aortic Valve Area Assessment

Noninvasive estimation of valve area in patients with aortic stenosis by Doppler ultrasound and two-dimensional echocardiography

Terje Skjæret, M.D., Lars Heggenaes, M.D., and Liv Hatle, M.D.

- Described in 30 subjects; 14 had significant AR
- Compared only to Fick and single plane CO angiography

Doppler Aortic Valve Area Assessment

- Continuity Equation
  \[ A_1 \times V_1 = A_2 \times V_2 \]
  \[ A_2 (AV) = \frac{A_1 \times V_1}{V_2} \]

- Also, \( A_2/A_1 = V_1/V_2 \)
- The ratio of velocities is the inverse of the ratio of areas
- Dimensionless index = \( V_1/V_2 < 0.25 \)
Doppler Aortic Valve Area Assessment

LVOT Diameter = 2 cm
LVOT Area = $0.785 \times (2)^2$
LVOT Area = 3.14 cm$^2$

- LVOT diameter
- Measure in systole
- At Leaflet insertion
- Error squared!!

LVOT assumed as a circle = $\pi r^2$
LVOT Area = $\pi (\text{LVOT radius})^2$
LVOT Area = $3.14 \times (\text{LVOT diameter}/2)^2$
LVOT Area = $0.785 \times (\text{LVOT diameter})^2$

Measurement Errors

20% > Echo

Discrepancy is worse with AS
**Doppler Aortic Valve Area Assessment**

- **PW: LVOT**
- Use proper cursor alignment parallel to blood flow to obtain optimum signal

LVOT Velocity = 1 m/sec
LVOT TVI = 25 cm

**Doppler Aortic Valve Area Assessment**

- **CW: AV**
- Multiple windows
- Use proper cursor alignment parallel to blood flow to obtain optimum

AV velocity = 4 m/sec
AV TVI = 98 cm
Doppler Gradient Assessment

Noninvasive assessment of pressure drop in mitral stenosis by Doppler ultrasound

L. Hatle, A. Brubakk, A. Tromsdal, and B. Angelsen

From Section of Cardiology, Medical Department, University Hospital, 7009 Trondheim; and Division of Engineering Cybernetics, The Norwegian Institute of Technology and Division of Automatic Control at the Foundation of Scientific and Industrial Control at the University of Trondheim, 7009 Trondheim, Norway

• Described in 10 subjects
• Extrapolated to aortic valve

Doppler Gradient Assessment

• Doppler
  • MIG = 4V_2^2 - 4V_1^2
  • MIG = 4V_2^2
  • Use MIG = 4V_2^2 - 4V_1^2
  • V_1 > 1.5 m/second
  • V_2 < 3 m/second
Doppler versus Catheter Gradient Assessment

- Catheterization
  - Peak to Peak
  - $P_{\text{mean Catheter}}$
- Doppler
  - $MIG (4V_2^2 - 4V_1^2)$
  - $P_{\text{mean Doppler}}$
  - $MIG$ always > PPG
- $P_{\text{mean Doppler}} - P_{\text{mean Catheter}} = \text{Prec}$

Not Pressure Recovery

- LV Pressure: Peak 200 mmHg
- Aortic Pressure: Peak 150 mmHg
- Cath Peak to Peak: 50 mmHg
- Doppler Velocity: 4.5 m/second
- Doppler Maximum Instantaneous Gradient: Peak: 81
- Doppler-Cath difference: 31 mmHg
Pressure Recovery

- Catheterization Gradient = Mean 40 mmHg
- Doppler Mean Gradient = 50 mmHg
- Pressure Recovery = 10 mmHg

Gradient Determinants

- Area
- Flow
- Jet Eccentricity
- Aortic root diameter
- Global LV afterload
Gradient Determinants

- Area: There is an inverse quadratic relationship
- $\Delta P = \frac{Q^2}{K \times EOA^2}$

Gradient Determinants

- Flow: There is a direct quadratic relationship
- Low Flow: SVI $< 35\text{ml/m}^2$
**Gradient Determinants**

- **Jet Eccentricity**
- For the Same GOA, an Eccentric Jet leads to a Higher Gradient

\[ \text{Vel} \ 0.7 \text{ m/s}, \ \text{MG} \ 23 \text{ mmHg}, \ \text{EOA} \ 0.2 \]

- No further increase beyond 30°

- **Aortic root diameter**
- The smaller the aortic root, the less energy loss, the more the pressure recovery, the lower the catheter gradient. This effect plateaus at a diameter of 30 mm (area 7 cm²)
Global Left Ventricular Afterload

Moderate AS and low compliance = Severe AS and normal compliance

Global Left Ventricular Afterload

\[
Z_{VA} = \frac{150 \text{ mmHg} + 26 \text{ mmHg}}{32 \text{ ml/m}^2} = 5.5 \text{ mmHg/ml·m}^{-2}
\]
Severe Aortic Stenosis with Normal Function

Area Gradient Match
Normal Ejection Fraction
Normal Cardiac Output

AVA < 1 cm²
ΔP_{mean} > 40 mmHg

Aortic Stenosis Area/Gradient Mismatch

Courtesy Heidi Connolly
Aortic Stenosis
Area Gradient Mismatch

Low flow (normal or reduced LVEF)
Mean Gradient <30-40mmHg
AVA <1.0cm²

True, Severe AS

Mild-Mod AS
Low Flow (pseudo AS)

Severe Aortic Stenosis with Normal Function

MIG: 100 mmHg

Severe Aortic Stenosis with Low Gradient

MIG: 36 mmHg

Area/Gradient Match
AVA<1cm²
ΔP_{mean}>40mmHg

Area/Gradient Mismatch
AVA<1cm²
ΔP_{mean}<40mmHg
Low EF Area Gradient Mismatch

Risk Stratify
Dobutamine Stress

Dobutamine Echocardiography

Baseline Doppler hemodynamics

Flow Reserve? > 20% SV

True Severe AS (D2) Ila

Pseudo Severe AS

Vm > 4.0 m/sec

AVA < 1.0 cm²

Mean gradient

AV Area
True Severe AS (D2) IIa

SVI 37 - 48
AVA 0.8 – 0.8 cm²
AV mean gradient 20 – 43 mmHg

Pseudo Severe AS

SVI 34 – 59 ml/m²
AVA 0.9 – 1.5 cm²
AV mean gradient 19 – 23 mmHg
Case

- 62 y/o male
- STEMI and subsequent CABG five years ago
- Recurrent heart failure x 3 months
Stroke Volume = CSA x TVI

= 0.785 \left( \right)^2 \times \\
= 53 \text{ cm}^3

LVSVI = \frac{53 \text{ cm}^3}{2.3 \text{ m}^2} = 23 \text{ cm}^3/ \text{ m}^2 (< 35 \text{ ml/m}^2)

Area_{AV} = \frac{0.785 \left( 2.2 \text{ cm} \right)^2 \times \left( \right)}{0.9 \text{ cm}^2, \text{ MG } 24 \text{ mmHg}}
Dobutamine Stress

LV Stroke Volume Index
26ml/m² – 40ml/m²

Mean AV Gradient
24 – 52mmHg

Valve Area
0.9cm² – 1.0cm²

Projected Aortic Valve Area

\[
AVA_{proj} = AVA_{rest} + VC \times (250 - Q_{rest})
\]

Valve Compliance (VC) = \[
\frac{AVA_{peak} - AVA_{rest}}{Q_{peak} - Q_{rest}}
\]

\[
Q_{mean} = \frac{\text{Stroke Volume}}{\text{LV ejection time}}
\]
LVOT

Rest
SV = 53ml
AVA = 0.9cm²
Q_{\text{mean}} = 171ml.s^{-1}

Velocity = 0.8m/s
TVI = 24cm

Peak
SV = 91ml
AVA = 1.0cm²
Q_{\text{mean}} = 325ml.s^{-1}

Velocity = 5.0m/s
TVI = 90cm

AVA_{\text{proj}} = 0.96cm²

Is This Too Complicated?

1. LVOT diameter (use the same rest / stress)
2. LVOT\_TVI (rest / stress)
3. AoV\_TVI (rest / stress)
4. Measure the ejection time
### Defining Low Flow?

**Stroke Volume Index vs Flow Rate**

\[
\text{Flow Rate} = \frac{\text{Stroke Volume}}{\text{Systolic Ejection Period}}
\]

Despite a similar stroke volume, those with moderate AS will have a higher flow rate than a patient with severe AS because a lower SEP.

---

**Resting Aortic Valve Area at Normal Transaortic Flow Rate Reflects True Valve Area in Suspected Low Gradient Severe Aortic Stenosis**

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Rest AVA, cm²</th>
<th>Stress AVA, cm²</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q &lt; 200 ml/s</td>
<td>48</td>
<td>0.74±0.12</td>
<td>0.89±0.25</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Q &gt; 200 ml/s</td>
<td>19</td>
<td>0.85±0.09</td>
<td>0.89±0.12</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Interpretation: If normal resting flow rate, the corresponding AVA is likely to be represent the true hemodynamic severity of the stenosis and further “flow correction” with SECHO is not likely required.

*J Am Coll Cardiol Img 2015*
Case

• 75 year old male
• Presents with dyspnea and syncope
• HTN (treated BP 150/75)
• Grade III/VI mid peaking systolic murmur LSB
Echocardiography
Normal EF Area Gradient Mismatch

- LVEF 55%
- AV Mean G 26mmHg
- AVA 0.8cm²
- AVA index 0.45cm²/m²
- LVEDV 88ml
- SVi 32 ml/m²

Aortic Stenosis Severity?

1. Mild
2. Moderate
3. Severe
4. Can’t tell
A: EDV = 115, ESV = 45,
SV = 115 - 45 = 70 ml
EF = 70/115 = 60%
BSA = 1.79
SVI = 39 ml/m²

B: EDV = 85, ESV = 35,
SV = 85 - 35 = 50 ml
EF = 50/85 = 60%
BSA = 1.79
SVI = 28 ml/m²

So why is the Flow Low?

- **Preload**: Small LV volume (LVH)
- **Contractility**: Despite EF normal, contractility (&EF) impaired for degree of LVH
- **Afterload**: Global LV afterload (Valve and Vascular)
Approach to Patients with Normal EF Area Gradient Mismatch

1. Is the patient symptomatic? (exercise testing)

2. Is the stenosis severe?

3. Is the patient hypertensive?

4. GLS/contractility & Diastolic Function/RWT?

5. Other Causes of Low Flow? Mitral regurgitation

Paradoxical LFLG Severe AS Global Left Ventricular Afterload

\[ Z_{VA} = \frac{150 \text{ mmHg} + 26 \text{ mmHg}}{32 \text{ ml/m}^2} = 5.5\text{mmHg/ml·m}^{-2} \]
Global Left Ventricular Afterload

Moderate AS and low compliance = Severe AS and normal compliance

Aortic Stenosis
Reverse Area/Gradient Mismatch
Elevated Gradient Despite non-critical AS

Reverse Area/Gradient Mismatch
AVA > 1 cm²
ΔP_{mean} > 40 mmHg

Causes of Reverse A/G Mismatch

- Errors of Measurement
- High Flow
- Pressure recovery
- Eccentric Jet
- Para-valvular Obstruction
- Prosthetic-valve specific
Errors of Measurements
Eccentric Mitral

Mitral Regurgitant Jet Versus Aortic Stenosis Jet

• Mitral regurgitation occupies IVC and IVR
Errors of Measurements
LVOT Measurement

• Measure in systole
• At leaflet insertion
• Error squared!!
• Echo underestimates LVOT by 17%

High Flow

• Aortic regurgitation
• Hyperdynamic states (dialysis, anemia)
• Dimensionless Index
Pressure Recovery

**Doppler**
- Pmean = 34 mmHg
- EOA = 0.6 cm²

**Catheterization**
- Pmean = 18 mmHg
- EOA = 1 cm²

\[ \text{APR} = 34 - 18 = 16 \text{ mmHg} \]
\[ \text{RPR} = \frac{16}{34} = 47\% \]

Energy Loss Index

- Energy loss Co-efficient
  \[ \text{ELCo} = \frac{\text{AVA} \times \text{AAa}}{\text{AAa} - \text{AVA}} \]

- AVA = aortic valve area, AAa = aortic area
- Energy loss index: ELCo/BSA
- ELI < 0.52-0.76 cm² has poor outcomes and severe AS
- More significant with increase flow and moderate aortic stenosis
Pressure Recovery/High Flow

EOA = 0.6 cm$^2$
AAd = 2.2 cm
AAa = 3.8 cm$^2$
ElCo = $\frac{3.8 \times 0.6}{3.8 - 0.6}$
ElCo = 0.72 cm$^2$
ELI = 0.72/BSA

Eccentric Jet

- Case:
- 29 y/o male
- Carries a diagnosis of Asymptomatic severe AS
- Quit Law School
Cardiac Catheterization $P_{\text{mean}} = 50 \text{ mmHg}$, $\text{AVA} = 1 \text{ cm}^2$

$\text{AVA} = 2.61 \text{ cm}^2$

$P_{\text{mean}} = 57 \text{ mmHg}$

$\text{MIG} = 91 \text{ mmHg}$

Eccentric Jet
Eccentric Jet: Echo

Aortic Diameter = 4.0 cm
Eccentric Jet
Reverse Area Gradient Mismatch
Elevated Gradient/GOA ok
Mean Gradient >40mmHg
AVA >1.0cm²
Increased Flow
Eccentric Jet
Dilated Aorta
Bicuspid Aortic Valves

Aortic Stenosis
Reverse Area Gradient Mismatch
Elevated Gradient/GOA ok
Mean Gradient >40mmHg
AVA >1.0cm²

Bicuspid Aortic Valves
Para-valvular Obstruction

- Sub-Aortic membrane
- Hypertrophic Obstructive Cardiomyopathy
- Supravalvular Obstruction
- Mitral valve Prosthesis

Sub-Aortic Membrane
**Sub-Aortic Membrane**

- Progressive Disease
- Other congenital anomalies in 50%
- VSD/PDA/Coarctation
- Shone’s Complex
- Bicuspid AV
- Left sided-SVC

Types: Membrane, fibromuscular ridge, Diffuse tunnel narrowing, mitral tissue

May Cause aortic regurgitation

Treatment: Surgery

No symptoms: Catheter LVOT-A peak/Doppler Mean = 50 mmHg

Symptoms: Catheter LVOT-A peak/Doppler Mean = 30-50 mmHg

Adults may use Doppler Peak > 50 mmHg

Resection/Konno procedure

**Hypertrophic Obstructive Cardiomyopathy**

- Alcohol Septal Ablation or Surgery
- High Risk features
- ICD
Supra-Aortic Obstruction

Non-Familial Sporadic
William syndrome:
  Elfin Facial
  Hypercalcemia
  Behavioral
  Diagnosed by CVS and fetal echo

Familial Sporadic
Coronary anomalies
Types: Hour glass, Membrane, Diffuse narrowing
Surgery

Obstruction by Mitral Valve Prosthesis
Aortic Stenosis Classification

Area/Gradient Match
- Area/Gradient Match NF/HG
- Area/Gradient Match LF/HG

Area/Gradient Mismatch Normal EF
- Area/Gradient Mismatch NF/LG
- Area/Gradient Mismatch LF/LG

Area/Gradient Mismatch Low EF
- True
- Pseudo
- Indeterminate

Reverse Area/Gradient Mismatch
- Flow Related
  1. Amount
  2. Eccentricity
- Supra/Sub Valve Obstruction
- Pressure Recovery
- Prosthetic Valve

Bicuspid Aortic Valve and Aortic Root

- Evaluate in Systole
- Fish Mouth
- Domed Appearance
Classifications

Bicuspid Aortic Valve: Classification 1
Bicuspid Aortic Valve

Distribution of valve morphology

<table>
<thead>
<tr>
<th>Valve dysfunction</th>
<th>Complete raphe</th>
<th>Incomplete raphe</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve dysfunction (n=144)</td>
<td>92 (62.9%)</td>
<td>52 (66.7%)</td>
<td>0.01</td>
</tr>
<tr>
<td>Aortic regurgitation (n=90)</td>
<td>63 (56.8%)</td>
<td>33 (42.3%)</td>
<td>0.05</td>
</tr>
<tr>
<td>Aortic stenosis (n=89)</td>
<td>55 (49.5%)</td>
<td>34 (43.6%)</td>
<td>NS</td>
</tr>
</tbody>
</table>

Bicuspid Aortic Valve: Ascending Aortic Measurements

- **Absolute diameter**: (4.2)4.5/5/5.5 cm
- **Ascending aortic index** (Ascending aortic diameter/BSA): >2.5 cm/m²
- **Aortic root or Ascending aortic area/height in meters**: > 10 cm²/m
Most patients will develop AS or AR
Most are LCC/RCC fusion
More aortic dilatation with RCC/NCC fusion than with LCC/RCC fusion
20-30% family members have BAV
Complete Raphe more AR and dilatation
Aortic Root Guidelines

<table>
<thead>
<tr>
<th>Aortic Root</th>
<th>Mean (cm)</th>
<th>SD</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>3.5-3.72</td>
<td>0.38</td>
<td>CT</td>
</tr>
<tr>
<td>Male</td>
<td>3.63-3.91</td>
<td>0.38</td>
<td>CT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Gene</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marfan</td>
<td>FBN1</td>
<td>Skeletal Features Ectopia lentis</td>
</tr>
<tr>
<td>Loeys-Dietz</td>
<td>TGFBR1</td>
<td>Skeletal Features Cleft palate/uvula</td>
</tr>
<tr>
<td></td>
<td>TGFBR2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ACTA2</td>
<td>Livedo reticularis PDA/BAV</td>
</tr>
<tr>
<td>Vascular Ehlers-Danlos</td>
<td>MYH11</td>
<td>PDA</td>
</tr>
<tr>
<td></td>
<td>COL3A1</td>
<td>Thin skin GI/uterine rupture</td>
</tr>
<tr>
<td>Turner</td>
<td>45,X</td>
<td>Skeletal Feature BAV/Coarctation</td>
</tr>
</tbody>
</table>

Aortic Root Dissection

• **Increased wall stress:**
  HTN
  Cocaine
  Pheo
  Weight lifting
  Trauma and deceleration
  Coarctation
Aortic Root Dissection

• Media abnormalities:
  Genetic
  Inflammatory
  Takayasu arteritis
  Giant cell arteritis
  Behcet arteritis
  Other:
    Pregnancy/PCKD/steroids

Bicuspid Aortic Valve Guidelines: Imaging

• Class I (C): Initial TTE for morphology, AS/AR, sinuses, ascending aorta and timing for intervention
• Class I (C): Serial studies > 4 depending on rate of progression and FH and annually if > 4.5 cm
• Class I (C): Internal diameter, perpendicular to axis of blood flow at widest diameter mid sinus level for the root
Aortic Root Guidelines: Imaging

- Class I (C): Internal diameter, perpendicular to axis of blood flow at widest diameter mid sinus level for the root
- Class I (C): Initial TTE for BAV, Marfan, Loeys-Dietz, TGFBR1,2, FBN1, ACTA2, MYH11 and at 6 months
- Class I (C): Marfan annual studies > 4 depending on rate of progression and FH and semiannually if > 4.5 cm or the others
- Class I (C): Initial TTE for Turner, if normal then q 5-10 years and annually if abnormal

Bicuspid Aortic Valve/Aortic Root Guidelines: Imaging Relatives

- Class I (C): Imaging for first degree relative of aortic root dilatation
- Class I (C): if patient has BAV, FBN1, TGFBR1,2, FBN1, ACTA2, MYH1, then counseling and genetic testing and imaging of relatives with the mutation only
- Class IIa (B): If first degree positive, image second degree relative
Bicuspid Aortic Valve Guidelines: Intervention

- Class I (B): Surgery if sinuses or ascending aorta > 5.5 cm
- Class IIa (C): Surgery if sinuses or ascending aorta > 5 cm and progression > 0.5 cm/year or FH dissection or experienced center and low STS
- Class I (C): surgery on the aorta during AVR for AR/AS if > 4.5 cm

Aortic Root Guidelines: Intervention

- Class 1 (C): Degenerative aneurysm then surgery > 5.5 cm or > 0.5 cm/y progression
- Class I (C): Surgery for > 4.5 cm if concomitant with AVR
- Class IIa (C): Surgery for Marfan in women desiring to be pregnant and root or ascending aorta > 4 cm
- Class IIa (C): Surgery for Marfan if aortic root or Ascending aortic area/height in meters: > 10 cm²/m
Aortic Root Guidelines: Intervention

- Class IIa (C): Surgery for Loeys-Dietz and TGFBR1,2 if sinuses or ascending aorta > 4.2 cm (TTE), 4.4-4.6 (CT/MR)
- Class IIa (C): Surgery for others 4-5 depending on situation

Pre Questions (1)

- The Difference between Doppler MIG and catheterization PPG
  
A. Is due to pressure recovery
B. Is due to different measurement timing of the LV and aortic pressures
C. Occurs only in patients with small aortas
D. Is used to calculate aortic valve area
Answer (1)

• B. Is due to different measurement timing of the LV and aortic pressures

Pre Questions (2)

• The Difference between Doppler MIG and catheterization PPG
  A. Is due to pressure recovery
  B. Is due to difference in the timing of the aortic pressure measurement between cath and echo
  C. Is due to difference in the timing of the LV pressure measurement between cath and echo
  D. Is related to the severity of aortic stenosis
Pre Questions (2)

B. Is due to difference in the timing of the aortic pressure measurement between cath and echo

Pre Questions (3)

• Catheter-Doppler Discordance maybe due to
  A. Pressure recovery
  B. Eccentric jet
  C. Very severe aortic stenosis
  D. HOCM
Pre Questions (3)

• A. Pressure recovery

Pre Questions (4)

• The most common form of bicuspid aortic valve is
  A. Fusion of the LCC/RCC
  B. Fusion of the LCC/NCC
  C. Fusion of the RCC/NCC
  D. Equal distribution of cusp fusion
Pre Questions (4)

A. Fusion of the LCC/RCC

THANK YOU