Stress-echocardiography to guide decision making in valvular heart disease: Low-Flow, Low-Gradient Aortic Stenosis

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Canada Research Chair in Valvular Heart Diseases

Disclosures: None
Low-EF, low-flow, low-gradient AS

- AVA $\leq 1.0 \text{ cm}^2$, mean gradient $\leq 40 \text{ mmHg}$ and LVEF $\leq 40\%$

- Approximately 5-10% of AS population

- High risk patients:
  - 3-year survival 50-60%
  - If operated (AVR): operative mortality: 8-30%
True Severe AS vs. Pseudo Severe AS?

True Severe AS

- Low Flow
- Normal Flow
- AVA
- ΔP

Pseudo Severe AS

- Low Flow
- Normal Flow
- AVA
- ΔP
Dobutamine-Sstress Echo

\[ \Delta P < 40 \]
\[ AVA \leq 1.0 \]

\[ \uparrow SV \geq 20\% \]

Contractile Reserve

\[ \Delta P \geq 40 \]
\[ AVA < 1.2 \]

True Severe AS

AVR ± CABG
(OR, Mortality: 5-8%)

\[ \Delta P < 40 \]
\[ AVA \geq 1.2 \]

Pseudo Severe AS

MEDICAL

\[ \Delta P < 40 \]
\[ AVA \leq 1.0 \]

Indeterminate

AVR (OR, Mortality: 12-33%)
TAVI? MEDICAL?
Case Study #1

Resting Echo

Dobutamine Stress Echo
Case Study #1

Resting Echo

SV = 53 ml
LVEF = 40%
Peak ∆P = 49 mmHg
Mean ∆P = 29 mmHg
AVA = 0.77 cm²

Dobutamine Stress Echo

SV = 73 ml
LVEF = 50%
Peak ∆P = 92 mmHg
Mean ∆P = 52 mmHg
AVA = 0.75 cm²
Case Study #1:

- **Contractile reserve:** Yes
- **Stenosis severity:** True-severe
Case Study #2

Resting Echo

SV = 34 ml
LVEF = 15%
Peak \( \Delta P \) = 18 mmHg
Mean \( \Delta P \) = 12 mmHg
AVA = 0.85 cm\(^2\)

Dobutamine Stress Echo

SV = 46 ml
LVEF = 25%
Peak \( \Delta P \) = 21 mmHg
Mean \( \Delta P \) = 13 mmHg
AVA = 1.2 cm\(^2\)
Case Study #2:

- **Contractile reserve:** Yes
- **Stenosis severity:** Pseudo-severe
## Case Study #3: Low-Flow, Low-Gradient, Aortic Stenosis

<table>
<thead>
<tr>
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<td>Mean Gradient (mm Hg)</td>
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<tr>
<td>AVA (cm²)</td>
<td>0.6</td>
<td>0.95</td>
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Case Study #3:

- **Contractile reserve:** Yes
- **Stenosis severity:** ?
Valvular Heart Disease

Projected Valve Area at Normal Flow Rate Improves the Assessment of Stenosis Severity in Patients With Low-Flow, Low-Gradient Aortic Stenosis

The Multicenter TOPAS (Truly or Pseudo-Severe Aortic Stenosis) Study

Claudia Blais, MSc; Ian G. Burwash, MD; Gerald Mundigler, MD; Jean G. Dumesnil, MD; Nicole Loho, MD; Florian Rader, MD; Helmut Baumgartner, MD; Rob S. Beanlands, MD; Boris Chayer, Eng; Lyes Kadem, Eng, PhD; Damien Garcia, Eng, PhD; Louis-Gilles Durand, Eng, PhD; Philippe Pibarot, DVM, PhD
Concept of the Projected AVA (250 mL/s)

Aortic Valve Area (cm²)

Mean Transvalvular Flow Rate (ml/s)

Projected AVA

* Peak AVA during DSE

Blais et al, Circulation 2006;113:711-721
Calculation of the Projected AVA

Blais et al, Circulation 2006;113:711-721

AVA_{projected} = 0.6 + 0.005 \times (250 - 135) = 1.18 \text{ cm}^2
### Case Study #3: Low-Flow, Low-Gradient, Aortic Stenosis

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<td>Projected AVA (cm²)</td>
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Projected AVA vs. Valve Weight

Clavel et al. JASE, ;23:380-6, 2010
Usefulness of Projected AVA to Predict Outcome

Multivariate predictors of overall mortality in 84 patients treated medically

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Hazard Ratio (95% CI)</th>
<th>p-value</th>
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<tr>
<td>Simplified AVAproj ≤ 1.2 cm²</td>
<td>HR: 2.7 [1.6-5.2], p&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Peak DSE</td>
<td>HR: 1.7 [1.1-2.5], p=0.01</td>
<td></td>
</tr>
<tr>
<td>LVEF ≤35%</td>
<td>HR: 1.6 [1.1-2.4], p=0.02</td>
<td></td>
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<tr>
<td>DASI ≤20</td>
<td>HR: 1.3 [0.5-3.5], p=0.6</td>
<td></td>
</tr>
<tr>
<td>Gender (female)</td>
<td>HR: 1.5 [0.6-3.9], p=0.4</td>
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<td>Age ≥70 years</td>
<td></td>
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Clavel et al. JASE, ;23:380-6, 2010
Usefulness of Dobutamine Stress Echo.

Dobutamine Stress Echo

- ↑ SV ≥ 20%
  - Contractile Reserve
    - ΔP_{mean} ≥ 40 & AVA < 1.2
      - Projected AVA ≤ 1.0
        - True Severe AS
          - AVR ± CABG
    - ΔP_{mean} < 40 & AVA ≥ 1.2
      - Projected AVA > 1.0
        - Pseudo-Severe AS
          - MEDICAL
  - No Contractile Reserve
    - ΔP_{mean} < 40 & AVA ≥ 1.2
      - Projected AVA > 1.0
        - Indeterminate
          - AVR/TAVI ? MEDICAL?
Case Study #4

- 76 y.o. woman
- Risk factors:
  - Obese, Hyperchol.
  - Hypertension, COPD
  - 3-vessel CAD
- CABG × 3: Aug 95
- MI: Jan 96
- CHF: LVEDD: 64 mm, LVEF 25%, BNP: 832 pg/ml
- Aortic stenosis, 2+ mitral regurgitation
- Current medication: ASA, ARBs, Statin, Digoxin, Brochodil.
Resting Echo

LVEF = 25%  
SV = 51 ml  
AVA = 0.8 cm²  
ΔP = 46 / 28 mmHg

Dobutamine Stress Echo

LVEF = 30%  
SV = 57 ml  
AVA = 0.8 cm²  
ΔP = 52 / 31 mmHg
Case Study #4:

- **Contractile reserve:** No
- **Stenosis severity:** Indeterminate

Caroline Cueff, Jean-Michel Serfaty, Claire Cimadevilla, Jean-Pierre Laissy, Dominique Himbert, Florence Tubach, Xavier Duval, Bernard Jung, Maurice Enriquez-Sarano, Alec Vahanian, David Messika-Zeitoun

Performance of MSCT Calcium score > 1651 AU to correctly differentiate severe from non-severe AS

Case study #4
Score: 2000

Cueff et al. Heart 97:721-6, 2011
Usefulness of DSE and MSCT

Dobutamine Stress Echo

- $\uparrow SV \geq 20\%$
  - Contractile Reserve
    - $\Delta P_{\text{mean}} \geq 40$ & $\text{AVA} < 1.2$
      - $\Delta P_{\text{mean}}$ & $\text{AVA}_{\text{Proj}} \leq 1.0$
        - True Severe AS
          - $\text{AVR} \pm \text{CABG}$
    - $\Delta P_{\text{mean}} < 40$ & $\text{AVA} \geq 1.2$
      - $\Delta P_{\text{mean}}$ & $\text{AVA}_{\text{Proj}} > 1.0$
        - Pseudo Severe AS
          - MEDICAL
  - No Contractile Reserve
    - $\uparrow SV < 20\%$
      - True Severe AS
        - AVR? (High Op. Risk)
          - TAVI? MEDICAL?
Risk Stratification using Contractile Reserve

Group I = contractile reserve
\( \Delta SV \geq 20\% \) under DSE

Group II = no contractile reserve

126 Patients

Monin et al, Circulation 2003;108:319-324
Outcome After Aortic Valve Replacement for Low-Flow/Low-Gradient Aortic Stenosis Without Contractile Reserve on Dobutamine Stress Echocardiography

Christophe Tribouilloy, MD, PhD,* Franck Lévy, MD,† Dan Rusinaru, MD,‡ Pascal Guéret, MD,‡ Hélène Petit-Eisenmann, MD,§ Serge Baleynaud, MD,¶ Yannick Jobic, MD,¶ Catherine Adams, MD,# Bernard Lelong, MD,** Agnès Pasquet, MD,†† Christophe Chauvel, MD,‡‡ Damien Metz, MD,§§ Jean-Paul Quéré, MD,* Jean-Luc Monin, MD, PhD‡

A

Total Population

B

Matched Patients

Tribouilloy et al. JACC, 53;1865-1873, 2009
Preoperative Contractile Reserve vs. Postoperative Ejection Fraction

<table>
<thead>
<tr>
<th></th>
<th>Group I (CR+)</th>
<th>Group II (CR-)</th>
</tr>
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<tbody>
<tr>
<td>Operative Mortality</td>
<td>6%</td>
<td>33%</td>
</tr>
<tr>
<td>2-year Survival</td>
<td>97±7%</td>
<td>90±5%</td>
</tr>
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</table>

66 Patients who underwent AVR

Quere et al, Circulation 2006;113:1738-1734
Case study #4: No Contractile Reserve
Logistic Euroscore: 60%

AVR ?
Case Study #4:

What would you do this patient?

1- AVR
2- Medical
3- TAVI
4- Heart transplant
Combined Impact of PPM and LV Dysfunction on Operative Mortality

1200 patients undergoing AVR

Operative Mortality (%)

Prosthesis-Patient Mismatch

- Non significant: 3% (P=0.05)
- Moderate: 5% (P=0.08)
- Severe: 23% (P<0.001)
- Severe: 67% (P<0.001)

LVEF < 40% (n = 123)
LVEF ≥ 40% (n = 1027)

Surgical Options if Anticipating PPM

- Use of better performing prosthesis
  - Newer generation supra-annular bioprosthesis
  - Stentless bioprosthesis
  - Newer generation mechanical prosthesis
  - Homografts / Ross operation
- Aortic root enlargement
- Transcatheter aortic valve implantation
- Acceptance of PPM in light of other clinical factors
Prosthesis-Patient Mismatch vs. Prosthesis Type: A Case-Match Study

Clavel et al., JACC, 53:1883–91, 2009
Recovery of LVEF in Patients with Severe AS and LV Systolic Dysfunction (LVEF<50%): TAVI versus AVR

Clavel Circulation, 122:1928-36., 2010
Case #4: Transapical Valve Implantation

Early Postop.  
Peak $\Delta P$: 14 mmHg  
Mean $\Delta P$: 7 mmHg
Usefulness of DSE and MSCT

Dobutamine Stress Echo

↑ SV ≥ 20 %

Contractile Reserve

ΔP_{mean} ≥ 40 & AVA < 1.2
AVA_{Proj} ≤ 1.0
MSCT: Ca+++ 

True Severe AS

AVR ± CABG

ΔP_{mean} < 40 & AVA ≥ 1.2
AVA_{Proj} > 1.0
MSCT: Ca+-

Pseudo Severe AS

MEDICAL

↑ SV < 20 %

No Contractile Reserve

ΔP_{mean} < 40 & AVA ≥ 1.2
AVA_{Proj} > 1.0
MSCT: Ca+-

True Severe AS

AVR/TAVI

ΔP_{mean} ≥ 40 & AVA < 1.2
AVA_{Proj} ≤ 1.0
MSCT: Ca+++

True Severe AS

AVR ± CABG
Usefulness of Dobutamine Stress Echo in Low-Flow, Low-Gradient AS

- Dobutamine stress echocardiography is essential for risk stratification and clinical decision making in low-flow, low-gradient AS
- The projected AVA: a new index to distinguish true severe from pseudo-severe AS
- Assessment of stenosis severity remains a major challenge in patients with no or poor contractile reserve: usefulness of MSCT
- Particularly important to avoid patient-prosthesis mismatch (PPM) when operating on these patients
- Transcatheter valve implantation: a new promising therapeutic avenue in patients with low-flow, low-gradient AS and no contractile reserve??
Usefulness of Dobutamine Stress Echo in Low-Flow, Low-Gradient AS and Preserved LV Ejection Fraction???
Usefulness of Projected AVA in Preserved LVEF, Low-Flow, Low-Gradient AS

42 patients
22 % had pseudo-severe AS

Percentage of correct classification by AVA_{proj}: 89 %

Clavel et al. ESC 2011
Please, join the Working Group in Valvular Heart Disease European Society of Cardiology
TOPAS Study

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- Helmut Baumgartner
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- Gerald Mundigler
- Robert Beanlands
- Jutta Bergler-Klein
- Patrick Mathieu
- Éric Larose
- Mario Sénéchal
- Christian Couture
- Julia Mascherbauer
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- Robert Moss
- Benjamin Chow
- Aliasghar Khorsand
- Philipp Pichler

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- Brenda Johnston
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- Vienna General Hospital, Vienna
- Munster U. Hospital, Munster

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- Zeineb Hachicha
- Christina Fuchs
- Claudia Blais
- Dania Mohty
- Philip Bartko

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