Managing the Low Output Low Gradient Aortic Stenosis Patient

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No disclosures
Valvular Stenosis
Severity of Aortic Stenosis

<table>
<thead>
<tr>
<th>Severity</th>
<th>Mean gradient</th>
<th>AVA</th>
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Low output, low gradient AS
Gradient <40
AVA <1.0

Reduced EF
Preserved EF
Case

66 y/o man – referred for AVR
Severe Class IV CHF x 1 year

Prior history of CABG 12 years ago
Known LV systolic dysfunction
   (EF 40% at time of CABG)
Mild AS – gradient 10 mmHg

Did well until five years ago
Progressive CHF
Rapid deterioration last year
Case

• Optimal GDMT
• Echo: EF 22% - severe AS – AVA 0.6
  Mean gradient 17 mmHg
• Outside cath
  Occluded SVG to RCA
  Patent SVG to OM
  Patent LIMA to LAD
Case

- Exam BP 95/70  P 88
  - JVP elevated 15 cm
  - Carotid 2+ parvus  2+ tardus
  - Lungs rales both bases
  - LV sustained and displaced
  - S1 normal  S2 single
  - 2/6 SEM RUSB with mid peak
  - S3 present
ECHO
Aortic Stenosis

Mean gradient
17 mmHg

AVA 0.6 cm²
(0.3 cm²/m²)
Case 1
What would you do now?

1. Right and left heart cath
2. Send to AVR
3. Send to TAVR
4. Dobutamine challenge
5. Increase medical therapy
## Valvular Stenosis

### Severity of Aortic Stenosis

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Reduced LV Function

Low output, low gradient AS
Gradient <40
AVA <1.0

Severe endstage critical AS
Mild AS LV dysfunction
Resting Hemodynamics
HR, BP, gradient, CO, AVA

Dobutamine
5 ug/kg/min

Repeat Hemodynamics
Increase by 5 ug/kg/min

Endpoints
Drop BP, VT, HR>120, symptoms
Normalize CO
30 ug/kg/min
Valvular Stenosis

Low output, low gradient AS

Dobutamine
30 ug/kg/min

Normalize CO
Gradient <30
AVA > 1.0 cm²
Mild Aortic Stenosis

Gradient
15 mmHg

Gradient
22 mmHg
Valvular Stenosis

Low output, low gradient AS

Dobutamine
30 ug/kg/min

Normalize CO
Gradient >40
AVA < 1.0 cm²
Severe Aortic Stenosis

Gradient
22 mmHg

Gradient
48 mmHg
Contractile Reserve

Increase in stroke volume
Peak dobutamine
> 20%
Valvular Stenosis

Low output, low gradient AS

Dobutamine
30 ug/kg/min

No change CO
(no reserve)
No Contractile Reserve

Gradient
32 mmHg

Gradient
26 mmHg
Aortic Stenosis

Base
Gradient 17 mmHg
AVA 0.6 cm²

Dobutamine
Gradient 48 mmHg
AVA 0.5 cm²
Valvular Stenosis

Low output, low gradient AS

- Normalize CO
  - Gradient <30
    - AVA > 1.0 cm²
    - Pseudo-stenosis
      Medical Rx

- Normalize CO
  - Gradient >40
    - AVA < 1.0 cm²
    - AVR

- No change CO (no reserve)
  - ?
Operative Mortality for AVR Based on Contractile Reserve

Op Mortality (%)

- Nish 02
- Monin 03
- Quiere 06
- Levy 08

No CR
CR
Low output AS: Contractile Reserve (CR)

No contractile reserve
High mortality no matter what you do

Monin et al
JACC 2001:37:2101-7
Recent Data – Low Output AS

Operative mortality improves over time
European Multicenter Study
217 pts
AVA < 1.0
EF < 35 %
Gradient < 30 mmHg

1990-1999: 20% mortality
2000-2009: 10% mortality

Levy JACC 2008:51:1466
Contractile Reserve: Aortic Stenosis
Later data

Pt Survival(%) vs. F/U (months)

Gp 1 AVR
Gp 2 AVR
Gp 1 med
Gp 2 med

Gp 1 contractile reserve
Gp 2 no reserve

Monin Circ 2003: 108 319
Recent Data – Low Output AS

If survive operation even with no contractile reserve

- Improve symptoms
  - 90% increase NYHA
- Improve EF
  - 65% increase EF
- Survival: 90% 3 yr

Quere Circ 2006 112:1738
No Contractile Reserve

- Gradient < 20 mmHg
- 6 Min walk < 300 ft
- Dobut EF > 35%
- CAD with viable myocardium
- No CAD

High Risk

Remember if pts survive operation
- Improve symptoms
- Increase ejection fraction
- 90% survival

Highest Risk
Low Output Low Gradient AS
Reduced Ejection Fraction

1. Remains a diagnostic and therapeutic dilemma

2. Dobutamine challenge
   ✓ Rule out “pseudo-stenosis”
     Peak gradient < 30 mmHg
   ✓ Presence of contractile reserve
     Increase SV > 20%
Low Output Low Gradient AS

If truly severe aortic stenosis, AVR improves symptoms, ejection fraction with good survival
Low output, low gradient AS
Gradient <40
AVA <1.0

Reduced EF

Preserved EF
Case

72 y/o woman – Class II-III DOE
Prior history PAF – PPM
HTN, DM, ASO

Two years progressive DOE
Now limited daily activity

One year ago – normal coronaries
Case

BP 165/94  P 70
JVP normal
Carotid 1+ parvus, 1+ tardus
LV localized

S4 | S1 | 2/6 | S2
LVO TVI 15
AV gradient 29 mmHg
AVA 0.7 cm²
LV cavity normal
LVH
EF 55 %
Aortic stenosis
Gradient 20 mmHg
AVA 0.7 cm²
What would you do now?

1. Right and left heart cath
2. Dobutamine challenge
3. AVR
4. TAVR
5. Medical treatment
Paradoxical Low-Flow, Low-Gradient Severe Aortic Stenosis Despite Preserved Ejection Fraction Is Associated With Higher Afterload and Reduced Survival
Zeineb Hachicha, Jean G. Dumesnil, Peter Bogaty and Philippe Pibarot
Circulation 2007;115:2856-2864; originally published online May 28, 2007;
DOI: 10.1161/CIRCULATIONAHA.106.668681
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Severe aortic stenosis and low transvalvular flow despite normal EF….. these patients have a poor prognosis...

normal flow patients, low-flow patients had a higher prevalence of female gender ($P<0.05$), a lower transvalvular gradient (32±17 versus 40±15 mm Hg; $P<0.001$), a lower LV diastolic volume index (52±12 versus 59±13 mL·m$^{-2}$; $P<0.001$), lower LV ejection fraction (62±8% versus 68±7%; $P<0.001$), a higher level of LV global afterload reflected by a higher valvulo-arterial impedance (5.3±1.3 versus 4.1±0.7 mm Hg · mL$^{-1}$ · m$^{-2}$; $P<0.001$) and a lower overall 3-year survival (76% versus 86%; $P=0.006$). Only age (hazard ratio, 1.04; 95% CI, 1.01 to 1.08; $P=0.025$), valvulo-arterial impedance $>5.5$ mm Hg · mL$^{-1}$ · m$^{-2}$ (hazard ratio, 2.6; 95% CI, 1.2 to 5.7; $P=0.017$), and medical treatment (hazard ratio, 3.3; 95% CI, 1.8 to 6.7; $P=0.0003$) were independently associated with increased mortality.

Conclusion—Patients with severe aortic stenosis may have low transvalvular flow and low gradients despite normal LV ejection fraction. A comprehensive evaluation shows that this pattern is in fact consistent with a more advanced stage of the disease and has a poorer prognosis. Such findings are clinically relevant because this condition may often be misdiagnosed, which leads to a neglect and/or an underestimation of symptoms and an inappropriate delay of aortic valve replacement surgery. (Circulation. 2007;115:2856-2864.)
Paradoxical Low Flow in AS despite preserved EF

Severe AS (AVA < 0.6 cm²/m²)
Preserved EF > 50%

Paradoxically low flow (PLF)
SVI < 35 ml/m²

35% Canadian Study
28% SEAS Study

Cramariuc et al JACC Imag 2:390, 2009
WHY?
Valve Area vs Peak Flow Velocity

Systemic Hypertension Common Two resistors in series

LV

AS

Ao

Systemic Arterioles
Aortic Stenosis

\[ \downarrow \]

Afterload

\[ \downarrow \]

LV Hypertrophy

\{ \}

Normalize Wall Stress
Aortic Stenosis

HTN

Afterload

LV Hypertrophy

Systemic Arterial Compliance

Neurohumoral Activation

Ventriculo-vascular Coupling

Myocardial Dysfunction

Diastolic Dysfunction

Interstitial Fibrosis

Adverse Remodeling

Interconnected pathways showing the effects of Aortic Stenosis and HTN on cardiac function and structural changes.
Overall survival in patients with AS and pEF
Normal flow (NF) vs Low flow (LF)

It would seem reasonable to operate on the symptomatic patients with low flow severe AS and preserved EF.
Low flow AS
Preserved EF
Gradient 29 mmHg
AVA 0.9 cm²

Mean LAP 32 mmHg
PA 75/35
Mean LAP 32 mmHg
PA 75/35

Mean LAP 12 mmHg
PA 35/18
Low flow Low Gradient Aortic Stenosis

Symptomatic

Lower BP

Normal EF
Symptomatic
BP controlled

AVR

Normal EF

Low flow Low Gradient
Aortic Stenosis