Transcatheter Aortic Valve Implantation: Evolving to Mainstream Therapy?

William D. Anderson, MD
Director, Exempla Structural Heart Program
Disclosures

• None!
TRADITION

JUST BECAUSE YOU’VE ALWAYS DONE IT THAT WAY
DOESN’T MEAN IT’S NOT INCREDIBLY STUPID.
Structural Heart Disease
Diversity of Therapeutic Targets

• Congenital Anomalies:
  – Atrial septum (ASD, PFO)
  – Ventricular Septum
  – Pulmonic Valve

• Acquired Heart Disease:
  – LAA (Watchman)
  – Mitral Valve (Mitraclip)
  – Aortic Valve (TAVI)
  – Others: paravalvular leaks, ventricular support
Exempla TAVI Program
Exempla TAVI Program

Larry

Curly

Thursday, January 31, 13
Exempla TAVI Program

Larry  Curly  Moe
ESJH: Hybrid OR
Team sport!
CS/IC both scrub *together*

Important team members:
Two IC
Two CS

*Imaging - X-ray, ECHO, CT*
OR support staff
Cath lab support staff
Perfusion (wet pump)
12-15 staff members in room
Calcific Aortic Stenosis

- Mechanism of stenosis is similar to atherosclerosis\(^1\)
  - Mainly solid calcium deposits within the valve cusps
  - Similar risk factors to Coronary Artery Disease (CAD)
  - High coincidence of CAD and AS in same individual\(^2\)
  - 7th, 8th and 9th decades of life


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Thursday, January 31, 13
## Aortic Stenosis

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jet velocity (m/s)</td>
<td>&lt;3.0</td>
<td>3.0–4.0</td>
<td>&gt;4.0</td>
</tr>
<tr>
<td>Mean gradient (mmHg)*</td>
<td>&lt;25</td>
<td>25–40</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Valve area (cm²)</td>
<td>&gt;1.5</td>
<td>1.0–.5</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>Valve area index (cm²/m²)</td>
<td></td>
<td></td>
<td>&lt;0.6</td>
</tr>
</tbody>
</table>

2008 Focused Update for the Management of Patients With Valvular Heart Disease: (J Am Coll Cardiol;52:e1–e142)

Thursday, January 31, 13
For patients with symptomatic, severe AS, SAVR offers striking mortality benefit. AVR should be withheld in such patients only when compelling contraindications exist.

ACC/AHA Guidelines

Severe Aortic Stenosis

- Vmax greater than 4 m/s
- AVA less than 1.0 cm²
- Mean gradient > 40 mm Hg

Undergoing CABG or other heart surgery?

Symptoms?

- Yes
- Equivocal
- No

Exercise test

- Normal
- Symptoms ↓BP

LV ejection fraction

Less than 0.50

Severe valve calcification, rapid progression, and/or expected delays in surgery

Class II Class IIb Class IIa Class I Class IIb

Aortic Valve Replacement

Clinical follow-up, patient education, risk factor modification, annual echo

Preoperative coronary angiography

Re-evaluation

(J Am Coll Cardiol 2008;52:e1-e142)
ACC/AHA Guidelines

Severe Aortic Stenosis

Vmax greater than 4 m/s
AVA less than 1.0 cm²
Mean gradient > 40 mm Hg

Undergoing CABG or other heart surgery?

 Symptoms?

 Yes
  Equivocal
   Exercise test
     Symptoms ↓BP
       Class I
       Class IIb
     Normal
       LV ejection fraction
         Less than 0.50
           Yes
             Severe valve calcification, rapid progression, and/or expected delays in surgery
           No
             Clinical follow-up, patient education, risk factor modification, annual echo

 No
  Re-evaluation
  Normal

Preoperative coronary angiography

(J Am Coll Cardiol 2008;52:e1-e142)
ACC/AHA Guidelines
ACC/AHA Guidelines

Severe Aortic Stenosis

- Vmax greater than 4 m/s
- AVA less than 1.0 cm²
- Mean gradient > 40 mm Hg

Undergoing CABG or other heart surgery?

- Yes
  - Symptoms?
    - Yes: Exercise test
      - Symptoms ↓BP
        - Less than 0.50
          - No: Severe valve calcification, rapid progression, and/or expected delays in surgery
    - No: LV ejection fraction
      - Normal
        - No
      - Less than 0.50
        - Yes: Aortic Valve Replacement

- No: Re-evaluation

Aortic Valve Replacement

Preoperative coronary angiography

Clinical follow-up, patient education, risk factor modification, annual echo

(J Am Coll Cardiol 2008;52:e1-e142)
Surgical AVR in Octogenarians: Mortality & Logistic Euroscore Risk Stratification (n=282)


30 Day Survival | 1 Year Survival
---|---
SOURCE TA ES>20 (Mean 36.1%) | 87.4% | 69.3%
SOURCE TF ES>20 (Mean 33.5%) | 93.1% | 81%
**Patients with Severe AS**

*How many receive therapy?*

Severe Symptomatic AS: Percent of patients treated

- **Untreated**
  - EU: 60%
  - US: 40%

- **Surgery**
  - EU: 30%
  - US: 70%
  - EU: 32%
  - US: 68%
  - EU: 41%
  - US: 59%

From David H Adams MD, “Current Standard of Care for Treating Severe Aortic Stenosis: Surgical Treatment”

sAVR for patient with AS
Why is it underutilized?

- Those expecting to live for more than 5 years are likely to derive significant benefit from AVR
- For those who survive 6 months after their operation, life expectancy matches that of age-matched controls

Life expectancy for US population (years)

<table>
<thead>
<tr>
<th>Age</th>
<th>Life Expectancy</th>
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<tbody>
<tr>
<td>65</td>
<td>18.2</td>
</tr>
<tr>
<td>70</td>
<td>14.7</td>
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<tr>
<td>75</td>
<td>11.5</td>
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<tr>
<td>80</td>
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</tr>
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<td>85</td>
<td>6.5</td>
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<tr>
<td>90</td>
<td>4.8</td>
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From David H Adams MD, “Current Standard of Care for Treating Severe Aortic Stenosis: Surgical Treatment”
Transcatheter Aortic Valve Implantation (TAVI)

- Alain Cribier - FIM implant in 2002
- Antegrade transseptal approach
- Cardiac standstill
- 22-24F Delivery System
- Bovine pericardial tissue
- Sustained hemodynamic improvement

Edwards SAPIEN™ THV

Cribier, Circulation 2002;106:3006
News Release

FOR IMMEDIATE RELEASE
Contact: Ronald Trahan, APR, Ronald Trahan Associates, Inc., +1 508-359-4005, x108

CardiAQ™ Valve Technologies reports cardiovascular medicine milestone: first-in-human nonsurgical percutaneous implantation of a bioprosthetic mitral heart valve

Nearly 50% of patients suffering from a diseased mitral heart valve with severe, symptomatic regurgitation are denied open-heart surgery because it is considered too risky; in the future, Transcatheter Mitral Valve Implantation (TMVI) may offer new hope for these patients.
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Valve Clinic

preoperative assessment
Valve Clinic

*preoperative assessment*

- weekly clinic *and* weekly conference
Valve Clinic

preoperative assessment

• weekly clinic and weekly conference
• 1-2 IC, 1-2 CS, CRNP + clinic staff
Valve Clinic

preoperative assessment

• weekly clinic and weekly conference
• 1-2 IC, 1-2 CS, CRNP + clinic staff
• Clinical assessment
  – STS score
  – non-STS risk
Valve Clinic

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• Cath (preferably RHC and LHC)
Valve Clinic

*preoperative assessment*

- weekly clinic *and* weekly conference
- 1-2 IC, 1-2 CS, CRNP + clinic staff
- Clinical assessment
  - STS score
  - non-STS risk
- TTE
- Cath (preferably RHC and LHC)
- CT
  - gated cardiac for annular size
  - runoff for aorta and iliofemoral vessels
CT Imaging

expertise required!
Sheath Insertion
Initial BAV
Valve Advancement
ECHO Findings
Mean Gradients & Valve Area

PARTNER Cohort B

Mean Gradient (mm Hg)

AVA (cm²)

Baseline | 30 Day | 1 Year | 2 Year | 3 Year
---|---|---|---|---
EOA | Mean Gradient

N = 158 | N = 137 | N = 84 | N = 65 | N = 9
N = 162 | N = 143 | N = 89 | N = 65 | N = 9

Makkar, TCT 2011

Thursday, January 31, 13
PARTNER Study Design
Inclusion Criteria

• **Severe AS:** Echo-derived AVA <0.8 cm\(^2\) (or AVA index <0.5 cm\(^2\)/m\(^2\)) and mean AVG >40 mm Hg *or* peak jet velocity >4.0 m/s

• **Cardiac Symptoms:** NYHA Functional Class ≥II

• **Cohort A - High surgical risk:** Predicted operative risk ≥15% (site surgeons x 2 and cardiologist); guideline = STS score ≥10

• **Cohort B - Inoperable:** risk of death or serious irreversible morbidity >50%
### Patient Characteristics - Inoperable

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>TAVR (n = 179)</th>
<th>Standard Rx (n = 179)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age – yr</td>
<td>83.1 ± 8.6</td>
<td>83.2 ± 8.3</td>
<td>0.95</td>
</tr>
<tr>
<td>Male sex (%)</td>
<td>45.8</td>
<td>46.9</td>
<td>0.92</td>
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<tr>
<td>STS Score</td>
<td>11.2 ± 5.8</td>
<td>12.1 ± 6.1</td>
<td>0.14</td>
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<tr>
<td>NYHA</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>I or II (%)</td>
<td>7.8</td>
<td>6.1</td>
<td>0.68</td>
</tr>
<tr>
<td>CAD (%)</td>
<td>67.6</td>
<td>74.3</td>
<td>0.20</td>
</tr>
<tr>
<td>Prior MI (%)</td>
<td>18.6</td>
<td>26.4</td>
<td>0.10</td>
</tr>
<tr>
<td>Prior CABG (%)</td>
<td>37.4</td>
<td>45.6</td>
<td>0.17</td>
</tr>
<tr>
<td>Prior PCI (%)</td>
<td>30.5</td>
<td>24.8</td>
<td>0.31</td>
</tr>
<tr>
<td>Prior BAV (%)</td>
<td>16.2</td>
<td>24.4</td>
<td>0.09</td>
</tr>
<tr>
<td>CVD (%)</td>
<td>27.4</td>
<td>27.5</td>
<td>1.00</td>
</tr>
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Makkar, TCT 2011
# Patient Characteristics - Inoperable

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<tr>
<td>PVD (%)</td>
<td>30.3</td>
<td>25.1</td>
<td>0.29</td>
</tr>
<tr>
<td>COPD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any (%)</td>
<td>41.3</td>
<td>52.5</td>
<td>0.04</td>
</tr>
<tr>
<td>Creatinine &gt; 2 mg/dL (%)</td>
<td>5.6</td>
<td>9.6</td>
<td>0.23</td>
</tr>
<tr>
<td>Atrial fibrillation (%)</td>
<td>32.9</td>
<td>48.8</td>
<td>0.04</td>
</tr>
<tr>
<td>Perm. pacemaker (%)</td>
<td>22.9</td>
<td>19.5</td>
<td>0.49</td>
</tr>
<tr>
<td>Pulmonary HTN (%)</td>
<td>42.4</td>
<td>43.8</td>
<td>0.90</td>
</tr>
<tr>
<td>Frailty (%)</td>
<td>18.1</td>
<td>28.0</td>
<td>0.09</td>
</tr>
<tr>
<td>Porcelain aorta (%)</td>
<td>19.0</td>
<td>11.2</td>
<td>0.05</td>
</tr>
<tr>
<td>Chest wall radiation (%)</td>
<td>8.9</td>
<td>8.4</td>
<td>1.00</td>
</tr>
<tr>
<td>Chest wall deformity (%)</td>
<td>8.4</td>
<td>5.0</td>
<td>0.29</td>
</tr>
<tr>
<td>Liver disease (%)</td>
<td>3.4</td>
<td>3.4</td>
<td>1.00</td>
</tr>
</tbody>
</table>
PARTNER Cohort B

All Cause Mortality

(Smith, TCT 2010)

HR [95% CI] = 0.54 [0.38, 0.78]
P (log rank) < 0.0001

Numbers at Risk

<table>
<thead>
<tr>
<th></th>
<th>TAVI</th>
<th>Standard Rx</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>179</td>
<td>179</td>
</tr>
<tr>
<td>6</td>
<td>138</td>
<td>121</td>
</tr>
<tr>
<td>12</td>
<td>122</td>
<td>83</td>
</tr>
<tr>
<td>18</td>
<td>67</td>
<td>41</td>
</tr>
<tr>
<td>24</td>
<td>26</td>
<td>12</td>
</tr>
</tbody>
</table>

Absolute Risk Reduction 20%
NNT = 5

Thursday, January 31, 13
PARTNER Study Design

Symptomatic Severe Aortic Stenosis

ASSESSMENT: High Risk AVR Candidate
3105 Total Patients Screened
Symptomatic Severe Aortic Stenosis

ASSESSMENT: High Risk AVR Candidate
3105 Total Patients Screened

Total = 1058 patients

n=700 High Risk

2 Trials: Individually Powered

n=358 Inoperable
Symptomatic Severe Aortic Stenosis

ASSESSMENT: High Risk AVR Candidate
3105 Total Patients Screened

Total = 1058 patients

n= 700
High Risk

2 Trials: Individually Powered

2 Trials: Individually Powered

n= 700
High Risk TF

ASSESSMENT: Transfemoral Access

High Risk TA

1:1 Randomization

TAVI Trans femoral

VS

Surgical AVR

Primary Endpoint: All Cause Mortality (1 yr)
(Non-inferiority)

n=358
Inoperable

Leon, TCT 2010
PARTNER Study Design

Symptomatic Severe Aortic Stenosis

ASSESSMENT: High Risk AVR Candidate
3105 Total Patients Screened

Total = 1058 patients

2 Trials: Individually Powered

n= 700
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TAVI Trans femoral

Primary Endpoint: All Cause Mortality (1 yr) (Non-inferiority)

n= 700
High Risk TA

1:1 Randomization

TAVI Trans femoral

VS Surgical AVR

n=358
Inoperable

ASSESSMENT: Transfemoral Access

1:1 Randomization

TAVI Trans femoral

Primary Endpoint: All Cause Mortality over length of trial (Superiority)

VS Standard Therapy (usually BAV)

Not In Study

Leon, TCT 2010

Thursday, January 31, 13
**Primary Endpoint:**
**All-Cause Mortality at 1 Year**

<table>
<thead>
<tr>
<th>Months (No. at Risk)</th>
<th>TAVR</th>
<th>AVR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>348</td>
<td>351</td>
</tr>
<tr>
<td>6</td>
<td>298</td>
<td>252</td>
</tr>
<tr>
<td>12</td>
<td>260</td>
<td>236</td>
</tr>
<tr>
<td>18</td>
<td>147</td>
<td>139</td>
</tr>
<tr>
<td>24</td>
<td>67</td>
<td>65</td>
</tr>
</tbody>
</table>

**Primary Endpoint:**

**All-Cause Mortality at 1 Year**

[Graph showing mortality rates over time for TAVR and AVR]
Primary Endpoint: All-Cause Mortality at 1 Year

No. at Risk

<table>
<thead>
<tr>
<th></th>
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<th>AVR</th>
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<tbody>
<tr>
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<td>65</td>
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Primary Endpoint: All-Cause Mortality at 1 Year

Thursday, January 31, 13
Primary Endpoint: All-Cause Mortality at 1 Year

HR [95% CI] = 0.93 [0.71, 1.22]
P (log rank) = 0.62
PARTNER 1A Trial
Clinical Outcomes

A. Death from Any Cause, Intention-to-Treat Population

- Hazard ratio, 0.90 (95% CI, 0.71–1.15)
- P=0.41

B. Death from Any Cause, As-Treated Population

- Hazard ratio, 0.98 (95% CI, 0.76–1.25)
- P=0.85

C. Stroke, Intention-to-Treat Population

- Hazard ratio, 1.22 (95% CI, 0.67–2.23)
- P=0.52

D. Death from Any Cause or Stroke, Intention-to-Treat Population

- Hazard ratio, 0.93 (95% CI, 0.73–1.18)
- P=0.55

No. at Risk

<table>
<thead>
<tr>
<th>Group</th>
<th align="right">Month 12</th>
<th align="right">Month 24</th>
<th align="right">Month 36</th>
</tr>
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<tbody>
<tr>
<td>TAVR</td>
<td align="right">348</td>
<td align="right">298</td>
<td align="right">260</td>
</tr>
<tr>
<td>Surgery</td>
<td align="right">351</td>
<td align="right">252</td>
<td align="right">236</td>
</tr>
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No. at Risk

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<tr>
<td>TAVR</td>
<td align="right">348</td>
<td align="right">287</td>
<td align="right">249</td>
</tr>
<tr>
<td>Surgery</td>
<td align="right">351</td>
<td align="right">246</td>
<td align="right">230</td>
</tr>
</tbody>
</table>
Primary Endpoint: KCCQ Overall Summary

PARTNER Cohort B: TAVI vs Med Rx

Cohen, AHA 2010
Cost Effectiveness: TAVR vs Control
PARTNER Cohort B

iCER: incremental cost-effectiveness ratio

$100,000 per LY

$50,000 per LY

ΔCost = $79,837
Δ LE = 1.59 years
ICER = $50,212/LYG

Reynolds, ACC 2011
## TAVI Complications
Sapien Valve (TF and TA)

<table>
<thead>
<tr>
<th></th>
<th>POOLED* (503 pts)</th>
<th>SOURCE (1038 pts)</th>
<th>VANCOUVER (250 pts)</th>
<th>PARIS (75 pts)</th>
<th>CA-Multictr (339 pts)</th>
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</thead>
<tbody>
<tr>
<td>Vascular (maj)** (%)</td>
<td>18.5</td>
<td>10.6</td>
<td>10.3</td>
<td>11.8</td>
<td>13.1</td>
</tr>
<tr>
<td>AR &gt;2+ (%)</td>
<td>10.9</td>
<td>4.7</td>
<td>5.0</td>
<td>5.3</td>
<td>7.7</td>
</tr>
<tr>
<td>Stroke (%)</td>
<td>4.0</td>
<td>2.5</td>
<td>3.0</td>
<td>4.0</td>
<td>2.3</td>
</tr>
<tr>
<td>New Pacemaker (%)</td>
<td>4.4</td>
<td>7.0</td>
<td>5.5</td>
<td>5.3</td>
<td>4.9</td>
</tr>
<tr>
<td>Renal Failure (%)</td>
<td>5.2</td>
<td>8.7</td>
<td>4.2</td>
<td>na</td>
<td>2.6</td>
</tr>
<tr>
<td>Coronary Obstr (%)</td>
<td>0.4</td>
<td>0.6</td>
<td>na</td>
<td>0</td>
<td>0</td>
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</tbody>
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Leon, TVT 2010
## TAVI Complications

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Leon, TVT 2010
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Leon, TVT 2010

* Thursday, January 31, 13
## TAVI Complications

Sapien Valve (TF and TA)

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Leon, TVT 2010
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Leon, TVT 2010
TAVI Complications
TAVI Complications
Aortic Regurgitation
Impact on Survival post TAVI

Figure 2. Survival Curves by Post-Procedural AR
Survival curves for post-procedural AR grade: 0 or 1 (group 1, blue), 2 (group 2, green), and 3 to 4 (group 3, red). Cumulative survival rates were calculated by the Kaplan-Meier method and compared with the log-rank test.
(A) Survival curves by post-procedural AR in the whole cohort.
(B) Survival curves in the patients who received the Edwards valve.
(C) Survival curves in the patients who received the CoreValve.
(D) Survival curves in the patients who had LVEF \( \geq 40\% \).
(E) Survival curves in the patients who had LVEF \( < 40\% \).

AR = Atrial regurgitation; LVEF = Left ventricular ejection fraction.
All Cerebrovascular Events (%)
Makkar, TCT 2011

Note: Percents are of patients in the trial (n/179).

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<th>≤ 30 Days</th>
<th>31 Days – 1 Year</th>
<th>1 Year – 2 Years</th>
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<tr>
<td>All CVA</td>
<td>p = 0.010</td>
<td>p = 0.387</td>
<td>p = 0.028</td>
</tr>
<tr>
<td>Ischemic Stroke</td>
<td>p = 0.017</td>
<td>p = 0.155</td>
<td>p = 0.083</td>
</tr>
<tr>
<td>Hemorrhagic Stroke</td>
<td>p = 0.316</td>
<td>p = 0.121</td>
<td>p = 0.415</td>
</tr>
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</table>

Thursday, January 31, 13
Sapien Valve Thrombosis

80 yo F s/p Sapien #23mm
  - MPG 10mmHg
  - DAPT started
DOE 10 mos later
TTE: thrombus
  - MPG 54mmHg
Coumadin x 3 mos
Sx and thrombus resolved
  - MPG 13mmHg

Cota et al, Article in Press, Jan 2013
Severe AS?

- LV dysfunction / low gradients / small AVA
  - DSE (or cath with Dobutamine)
- Paradoxical Low Flow / Low Gradient
  - Normal LV systolic fxn, small AVA
- Max symptoms but only moderate AS (AVA 1.0-1.2cm²)
- Severe AS and severe MR
- Prosthetic valve dysfunction
Conclusions
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  – Who is too sick for TAVI?
  – What to do with patient profiles excluded from PARTNER/CoreValve Trials?
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Patient selection is KEY!

- Questions:
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  - What to do with patient profiles excluded from PARTNER/CoreValve Trials?
- Nature will fight back! Iterative changes in technology will reduce procedural complications.
Severe Aortic Stenosis
(n=622)

Survival Free of Symptoms

1 year: 82%
2 years: 67%
5 years: 33%

Pellikka et al, Circulation
2005;111:3290-3295
Severe Aortic Stenosis
(n=622)

Survival Free of Symptoms

Markers of poor outcome:
1. Advanced age
2. Heavy Ca++
3. Velocities >4m/sec

Pellikka et al, Circulation
2005;111:3290-3295
Paravalvular Aortic Regurgitation
PARTNER Cohort A

% Patients

P < 0.001

\begin{table}
\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Category} & \textbf{TAVR} & \textbf{AVR} & \textbf{TAVR} & \textbf{AVR} & \textbf{TAVR} & \textbf{AVR} \\
\hline
\textbf{30 Days} & & & & & & \\
\textbf{6 Months} & & & & & & \\
\textbf{1 Year} & & & & & & \\
\hline
\end{tabular}
\end{table}

\begin{itemize}
\item None
\item Trace
\item Mild
\item Moderate
\item Severe
\end{itemize}
# Echo Findings

## Paravalvular Regurgitation

<table>
<thead>
<tr>
<th>Finding – no. (%)</th>
<th>30 Days</th>
<th>1 Year</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TAVR</td>
<td>AVR</td>
<td>p-value</td>
</tr>
<tr>
<td>None</td>
<td>65 (22.6)</td>
<td>168 (73.7)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Trace/Mild</td>
<td>187 (65.2)</td>
<td>58 (25.4)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Mod/Severe</td>
<td>35 (12.2)</td>
<td>2 (0.9)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>73 (32.9)</td>
<td>123 (77.8)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>134 (60.4)</td>
<td>32 (20.3)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>15 (6.8)</td>
<td>3 (1.9)</td>
<td>&lt;.0001</td>
</tr>
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Smith, ACC 2011
Alternatives to sAVR
BAV Registry (n=674)

BAV:
- High recurrence rate: 50% in six months\(^1,2\)
- Absence of mortality benefit\(^1,2\)
- Inability to substantially alter leaflet morphology

\(^1\)Otto CM, Mickel MC, et al. Circulation 1994; 89: 642-50
\(^2\)Rahmitoola SH. J Am Coll Cardiol 1994; 23: 1076-78.
Has BAV Improved?
PARTNER Cohort B

All-cause mortality (%)

Months

0 6 12 18 24

Smith, TCT 2010

50.7%!