Long-Term Outcome of Patients With Aortic Regurgitation: Medical Management and Surgical Indications

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Goals in Treatment of Patients with Valve Disease

- Alleviate symptoms
- Avoid catastrophes
  - progressive CHF
  - sudden pulmonary edema
  - infective endocarditis
  - thromboemboli
  - sudden death
- Avoid early mortality
When is the proper time for surgical intervention?
Problems with Valve Replacement

- Perioperative mortality and morbidity

- Late valve problems

<table>
<thead>
<tr>
<th></th>
<th>Mechanical</th>
<th>Biologic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Durability</strong></td>
<td>For life of patient</td>
<td>5 - 20 yrs</td>
</tr>
<tr>
<td><strong>Thromboembolism</strong></td>
<td>Mitral 3%/yr</td>
<td>? Atrial fib</td>
</tr>
<tr>
<td></td>
<td>Aortic 1%/yr</td>
<td></td>
</tr>
<tr>
<td><strong>Anticoagulants</strong></td>
<td>+</td>
<td>? Atrial fib</td>
</tr>
<tr>
<td><strong>Valve regurgitation</strong></td>
<td>3-5% (1% severe)</td>
<td></td>
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<tr>
<td><strong>Infecive endocarditis</strong></td>
<td>1% first yr, 0.5%/yr after</td>
<td></td>
</tr>
<tr>
<td><strong>Late mortality</strong></td>
<td>3-4%/yr</td>
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</table>
Long-Term Survival After Valve Replacement

AVR 394  
MVR 191  

Randomized in OR  
Biologic vs Mechanical  

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.
# Outcomes After 15 years

Hammermeister K, et al JACC 2000; 36:1152

<table>
<thead>
<tr>
<th>Thromboembolism</th>
<th>Biol</th>
<th>Mech</th>
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<tbody>
<tr>
<td>Aortic</td>
<td>18%</td>
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<tr>
<td>Mitral</td>
<td>22%</td>
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</table>
LV END SYSTOLIC PRESSURE

END SYSTOLIC PRESSURE – VOLUME RELATIONSHIP

LV END DIASTOLIC PRESSURE
Normal

First beat

Subsequent beats

EFFECT OF DECREASED CONTRACTILITY
Aortic Regurgitation - Pathophysiology

- AR is both a volume overload and an afterload burden
- Regurgitant volume increases LVEDV - eccentric hypertrophy
- Increased LV stroke volume $\uparrow$ Systolic and $\downarrow$ diastolic aortic pressure - $\uparrow$ pulse pressure
- Peripheral signs related to wide pulse pressure and to rapid diastolic runoff
Common Etiologies of AR

**Acute AR**
- Infective endocarditis
- Dissection of the aorta
- Trauma
- Prosthetic valve disruption

**Chronic AR**
- Rheumatic heart disease
- Bicuspid aortic valve
- Ascending aortic aneurysm
- Aortitis - lues, granulomatous, Takayasu’s, Giant cell
- Spondylitis
- Hypertension
- Prolapse
- Marfan, Ehlers-Danlos, Reiter’s
- Discrete subaortic stenosis
- VSD with prolapsed cusp
- Anorectic drugs
### Natural History of Asymptomatic Patients With Chronic AR

<table>
<thead>
<tr>
<th>Study (yr)</th>
<th># Pts</th>
<th>Mean F-U (yrs)</th>
<th>Progression (%/yr)</th>
<th>Mort (# Pts)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Sx, death, LV dys)</td>
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<tr>
<td>Bonow (1983)</td>
<td>104</td>
<td>8</td>
<td>3.8</td>
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<td>Scognamiglio (1986)</td>
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<tr>
<td><strong>Average</strong></td>
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<td>Mort (# Pts)</td>
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Chronic Aortic Regurgitation
Natural History

- Congestive Heart Failure - 90% dead within two years
- NYHA Class III - IV - 37% five year survival
- “Free” aortic regurgitation - 50% ten year survival
- Trivial aortic insufficiency - 90% ten year survival
AR — PROPOSED MECHANISM OF DECREASED LV FUNCTION

AR

↑ SV

↑ PP

Dilates Aorta

Aortic Wall Stress

Compromises vasa vasora

Fragnents Elastic Fibers

↑ Collagen

↑ Age

↓ Aortic Distensibility

↑ Afterload on LV

? ↓ Cor Blood Flow

LV Dysfunction

Atherosclerosis
50 Asx AR pts
F-U time 44 months
Progressed to AVR-10
Annual Rate - 4±3%

ESVI < 60 cc/m² (n=35)

ESVI ≥ 60 cc/m² (n=15)

P = 0.0009

C

Asymptomatic Pts with Severe Aortic Regurgitation


104 pts with severe aortic regurgitation
Ave follow-up  7.3 years
39/104 reached a cardiac endpoint -
died suddenly, developed symptoms,
developed LV dysfunction with or
without symptoms
  4 died suddenly
  22 developed Sx
  13 developed LVdx with or without Sx

Progression rate 6.2% / yr
Asymptomatic Pts with Severe AR


For development of Asx LV dysfunction
the strongest univariate was
Absolute LVEF with exercise

Highest risk- exer LVEF ≤49% - 8.8%/yr
Lowest risk- Exer LVEF ≥57% - 0%/yr
Chronic Aortic Regurgitation - Indications for Surgery

Class 1
1. Symptomatic patients with severe AR irrespective of systolic function (B)
2. Asx patients with chronic severe AR and EF ≤0.50 at rest. (B)
3. Chronic severe AR undergoing CABG, surgery on aorta or other valves. [C]

Class Ila
1. Asx patients with chronic severe AR, EF >0.50, but with severe LV dilatation (EDD >75 mm or ESD > 55mm). (B)

Class IIb
1. Patients with moderate AR undergoing surgery on ascending aorta. [C]
2. Patients with moderate AR undergoing CABG. [C]
3. Asx patients with severe AR and EF ≥0.50 when LV dilatation > EDD 70 mm or ESD ≥ 50 mm when there is evidence of progressive LV dilatation, declining exercise tolerance, or abnormal hemodynamic response to exercise. [C]

Class III
1. Not indicated for Asx patients with mild, moderate or severe AR and EF >0.50 when degree of LV dilatation is not moderate or severe (EDD < 70 mm, ESD < 50 mm). (B)

Bonow RO, et al Circulation 2006; 114: e84
Functional Anatomy of AR: Accuracy, Prediction of Surgical Repairability and Outcome Implications of TEE


163 consecutive patients undergoing AR surgery

Mechanisms of AR categorized by preop TEE and at surgery as

- Type 1 aortic dilatation
- Type 2 aortic cusp prolapse
- Type 3 restrictive cusp motion or endocarditis

At surgery - mechanisms classified
  - Type 1 - 41 pts
  - Type 2 - 62 pts
  - Type 3 - 60 pts

Agreement between TEE and surgery 93% (Kappa = 0.90)

Valve repair 125 pts, AVR 38 pts

TEE predicted final surgical approach in 86% of pts undergoing repair
  and in 93% undergoing AVR
  and was determinant of valve repairability and postop outcome

(4-year freedom from > grade 2 AR, reoperation or death p= 0.04)
Long-Term Outcome of Surgically Treated Aortic Regurgitation: Influence of Guideline Adherence Toward Early Surgery

170 patients with chronic severe AR who had AVR

Group A - Followed guidelines - 60
Group B - Operated late according to guidelines - 110

Group A: Asx with LVEF 45-50% +/- or ESD 50-55 mm and NYHA II
Group B: NYHA III-IV or with LVEF < 45% or ESD > 55 mm

Prospectively followed-up 10±6 years

Tornos P, et al. JACC 2006; 47:1012
Long-Term Outcome of Surgically Treated Aortic Regurgitation: Influence of Guideline Adherence Toward Early Surgery

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Prospectively followed-up 10±6 years

Results:

44 died - Group A - 7 (12%)  P= 0.001
Group B - 37 (37%)

Causes of death
Sudden death or heart failure
Group A - 1 patient  P= 0.001
Group B - 20 patients

Tornos P, et al. JACC 2006; 47:1012
Overall Survival According to Group

Tornos P, et al. JACC 2006; 47:1012

<table>
<thead>
<tr>
<th>Group A</th>
<th>90±4%</th>
<th>86±5%</th>
<th>78±7%</th>
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</thead>
<tbody>
<tr>
<td>Group B</td>
<td>75±8%</td>
<td>64±5%</td>
<td>53±6%</td>
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</table>
## Echocardiographic Parameters During Follow-Up in Study Groups

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group A</th>
<th>Group B</th>
<th>p-value</th>
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<tbody>
<tr>
<td><strong>EDD (mm)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preop</td>
<td>71±7</td>
<td>75±8</td>
<td>0.001</td>
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<tr>
<td>1-yr postop</td>
<td>53±6</td>
<td>59±12</td>
<td>0.0001</td>
</tr>
<tr>
<td>Final F-U</td>
<td>53±7</td>
<td>57±9</td>
<td>0.021</td>
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<tr>
<td><strong>ESD (mm)</strong></td>
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<td></td>
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<tr>
<td>Preop</td>
<td>48±6</td>
<td>55±10</td>
<td>0.0001</td>
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<tr>
<td>1-yr postop</td>
<td>38±6</td>
<td>44±14</td>
<td>0.0001</td>
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<tr>
<td>Final F-U</td>
<td>36±7</td>
<td>40±11</td>
<td>0.023</td>
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<tr>
<td><strong>LVEF (%)</strong></td>
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<tr>
<td>Preop</td>
<td>54±7</td>
<td>42±10</td>
<td>0.0001</td>
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<tr>
<td>1-yr postop</td>
<td>57±9</td>
<td>47±16</td>
<td>0.0001</td>
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<tr>
<td>Final F-U</td>
<td>55±9</td>
<td>51±12</td>
<td>0.047</td>
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Tornos P, et al. JACC 2006; 47:1012
Aortic Regurgitation - Load Dependence Of Effective Regurgitant Orifice Area


Presumed mechanism of afterload reduction in AR is redistribution of LVSV
?

Mechanism is reduction in regurgitant orifice

10 open chest sheep - partial resection of aortic noncoronary cusp

Regurgitant flow - supravalvular flowmeter - pressures with micromanometer

Regurgitant orifice measured after AR created, with BP ↑ 15-25 mm Hg by dopamine
↓ 15-25 mm Hg by nitroprusside
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<tr>
<th>Results:</th>
<th>Regurg Vol</th>
<th>Regurg Orifice</th>
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<tbody>
<tr>
<td>Dopamine</td>
<td>↑ 86±81% *</td>
<td>↑ 38±44% *</td>
</tr>
<tr>
<td>Nitrprusside</td>
<td>↓ 51±14% **</td>
<td>↓ 28±21% ***</td>
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</table>

* p<0.01
** p<0.001
*** p<0.007
Hydralazine vs Placebo in Asx Chronic Severe AR

## Nifedipine in ASx Aortic Regurgitation

Scogamiglio, R et al, NEJM 1994;331:689

$n = 143$ Randomized to nifedipine 20 mg BID (69 pts) or digoxin 0.25 mg/d (74 pts) - Follow-up 6 yrs

<table>
<thead>
<tr>
<th></th>
<th>EDVI</th>
<th>ESVI</th>
<th>EF</th>
<th>MASS</th>
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<tbody>
<tr>
<td></td>
<td>ml/m²</td>
<td>%</td>
<td>g/m²</td>
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<td><strong>Nifedipine</strong></td>
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<tr>
<td>Before</td>
<td>126+/−16</td>
<td>52+/−9</td>
<td>64+/−4</td>
<td>139+/−16</td>
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<tr>
<td>End</td>
<td>112+/−28</td>
<td>51+/−22</td>
<td>62+/−14</td>
<td>108+/−34</td>
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<tr>
<td><strong>Digoxin</strong></td>
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<tr>
<td>Before</td>
<td>128+/−22</td>
<td>49+/−8</td>
<td>62+/−6</td>
<td>134+/−18</td>
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<tr>
<td>End</td>
<td>140+/−25</td>
<td>56+/−19</td>
<td>58+/−14</td>
<td>142+/−22</td>
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<tr>
<td><strong>P value</strong></td>
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<tr>
<td>NvD before</td>
<td>ns</td>
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<tr>
<td>NvD end</td>
<td>0.003</td>
<td>0.004</td>
<td>0.03</td>
<td>0.02</td>
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At end of follow-up or at valve replacement
Incidence of AVR

Scognamiglio R, et al NEJM 1994; 331:689
Disruption of Angiotensin II type 1a Receptor -
Effect on Long-term Survival in Chronic, Severe AR in Mouse Model


**Hypothesis:** AT II type 1 receptor (AT 1) blockade can prevent LV remodeling in chronic AR and improve survival

Severe AR produced in wild type (WT) mice and AT I knockout (KO) mice

Mice surviving 4 weeks were considered chronic severe AR
Followed 50 weeks - WT 29, KO 31
Chronic AR in AT II Type 1a Receptor KO Mice - Survival

Survival at Baseline Four Weeks

LV Diastolic Diameter

% Fractional Shortening

LV Weight / Body Weight

Sirius Red stain - Interstitial collagen

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**Baseline Echo 4 weeks after surgery - LV cavity and function same in both genotypes**

16 weeks after baseline, KO mice had less LV dilatation, hypertrophy and interstitial fibrosis than WT mice

50 week mortality was significantly lower among KO mice

KO 45.2%
WT 86.2%
Aortic Regurgitation - Hydralazine vs Enalapril

70 pts  Mod - severe asymptomatic AR
Randomized to Enalapril 5 mg to 20 mg/d
or Hydralazine 25 mg to 100 mg/BID
35 pts to each group

2-D echo at baseline, 6 mo and 1 yr
LVEDI, LVESI, LV Mass, LVmean wall stress,
LVEF, Treadmill exer time, RAAS, ADH,
and Aldosterone

Lin M, et al. JACC 1994;24:1046
# Aortic Regurgitation

## Hydralazine vs Enalapril

### Echo Results

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<tr>
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<th>Hydralazine Baseline</th>
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<tr>
<td>LVEDVI</td>
<td>124+/-23</td>
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<td>122+/-25</td>
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<td>LVESVI</td>
<td>50+/-18</td>
<td></td>
<td>49+/-20</td>
<td></td>
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<tr>
<td>EF</td>
<td>60+/-15</td>
<td></td>
<td>60+/-20</td>
<td></td>
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<tr>
<td>LVWS</td>
<td>389+/-38</td>
<td></td>
<td>391+/-40</td>
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<td>LVMASS</td>
<td>130+/-24</td>
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<td>128+/-26</td>
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** p< 0.01, *** p< 0.005, **** p< 0.001

Lin M, et al. JACC 1994;24:1046
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<td></td>
<td>Baseline</td>
<td>1 Yr</td>
</tr>
<tr>
<td><strong>PRA</strong> (ng/ml/hr)</td>
<td>1.53 +/-1.13</td>
<td>2.29 +/-1.19 *</td>
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<tr>
<td><strong>ALD</strong> (ng/dl)</td>
<td>18.9 +/-11.1</td>
<td>15.1 +/-9.8</td>
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<tr>
<td><strong>ADH</strong> (pq/ml)</td>
<td>1.55 +/-0.98</td>
<td>1.41 +/-0.94</td>
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* p < .05

p < .01 & Hydralazine > Enalapril p < .001
Long-Term Vasodilator Therapy in Patients With Severe Chronic AR

Randomly assigned 95 patients with Asx, severe AR and normal EF

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<tr>
<th>Therapy</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nifedipine</td>
<td>20 mg q 12 hr</td>
</tr>
<tr>
<td>Enalapril</td>
<td>20 mg/d</td>
</tr>
<tr>
<td>No Rx</td>
<td></td>
</tr>
</tbody>
</table>

At 7 years:
- Nifedipine: 41%
- Enalapril: 50%
- No Rx: 39%

Long-Term Vasodilator Therapy in Patients With Severe Chronic AR

Long-Term Results of AVR in Patients With Chronic AR
Influence of Prior Medical Therapy on Results

Surgery indicated when EF fell < 50%

Treated with nifedipine before surgery
Average treatment before surgery 7.8 yrs

Yes
134 (Group A)

No
132 (Group B)

Op mortality
0.75%
0.76%

EF normalized
100%
72%

p Value
ns
<0.01

Scognamiglio R, et al. JACC 2005;45:1025
Survival After Surgery of Chronic AR Patients

Scognamiglio R, et al. JACC 2005;45:1025
Long-Term Results of AVR in Patients With Chronic AR
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Surgery indicated when EF fell < 50%

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Average treatment before surgery 7.8 yrs

<table>
<thead>
<tr>
<th></th>
<th>Yes (Group A)</th>
<th>No (Group B)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Op mortality</td>
<td>0.75%</td>
<td>0.76%</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>EF normalized</td>
<td>100%</td>
<td>72%</td>
<td></td>
</tr>
</tbody>
</table>

At 10 Year Follow-up

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>LVEF</td>
<td>62±5 %</td>
</tr>
<tr>
<td>10 Year survival</td>
<td>85±4 %</td>
</tr>
</tbody>
</table>

Scognamiglio R, et al. JACC 2005;45:1025
Role of Vasodilators in AR

- Vasodilators can reduce LVEDV and LVESV increase LVEF
- There are many small studies that support use in Asx patients
- There are two randomized studies with opposite results
- Vasodilators can be used in Asx patients with moderate - severe AR but are not substitutes for AVR if symptoms occur or EF falls
SO LONG.......THANKS for listening
QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.
Pathophysiology of Acute MR and AR

**Normal**
- LAP 10
- EDV 120
- ESV 50

**Acute MR**
- LAP 25
- TSV 70
- FSV 70
- RSV 0
- EDV 140
- ESV 40
- EF .72

**Acute AR**
- LAP 25
- EDV 150
- ESV 50
- TSV 100
- FSV 50
- RSV 50
- EF .66
## Aortic Regurgitation - Hydralazine vs Enalapril

### Hemodynamic Data

<table>
<thead>
<tr>
<th></th>
<th>Enalapril</th>
<th></th>
<th>Hydralazine</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
<td>1 Yr</td>
<td>Base</td>
<td>1 Yr</td>
</tr>
<tr>
<td>HR</td>
<td>75 +/- 7</td>
<td>72 +/- 7</td>
<td>75 +/- 8</td>
<td>77 +/- 8</td>
</tr>
<tr>
<td>SysBP</td>
<td>173 +/- 17</td>
<td>138 +/- 12</td>
<td>171 +/- 18</td>
<td>138 +/- 9</td>
</tr>
<tr>
<td>DiaBP</td>
<td>82 +/- 13</td>
<td>71 +/- 9</td>
<td>81 +/- 13</td>
<td>70 +/- 9</td>
</tr>
<tr>
<td>Ex Dur</td>
<td>6.3 +/- 2.6</td>
<td>6.9 +/- 2.5</td>
<td>6.3 +/- 2.7</td>
<td>6.8 +/- 2.7</td>
</tr>
</tbody>
</table>

* p =< .05

* * p = <.005

Lin M, et al. JACC 1994;24:1046
Survival After Surgery of Chronic AR Patients

Scognamiglio R, et al. JACC 2005;45:1025
Survival - Prosthetic Valves

% Survival

Months after Operation

87%

75%

Alsip, Am J Med Vol. 78 (Suppl. 6B), 28 June 85
Representative TEE examples of the 4 subtypes of type 2 AR lesions.  
C, Whole cusp prolapse.  D, Fee edge fenestration.
Dynamic Nature of Aortic Regurgitant Orifice During Diastole