

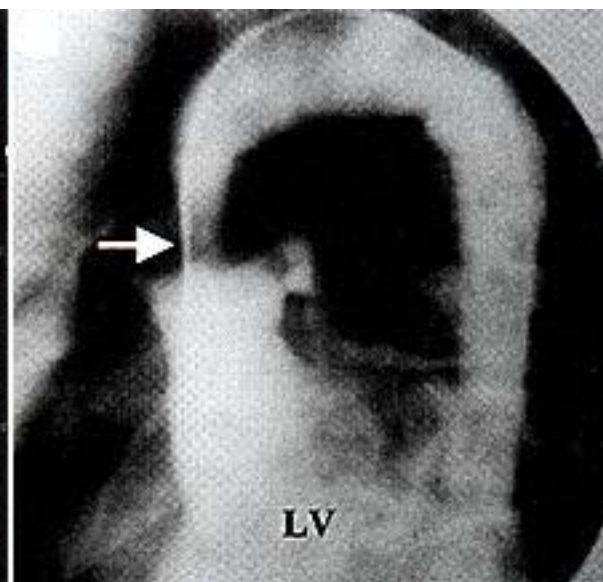
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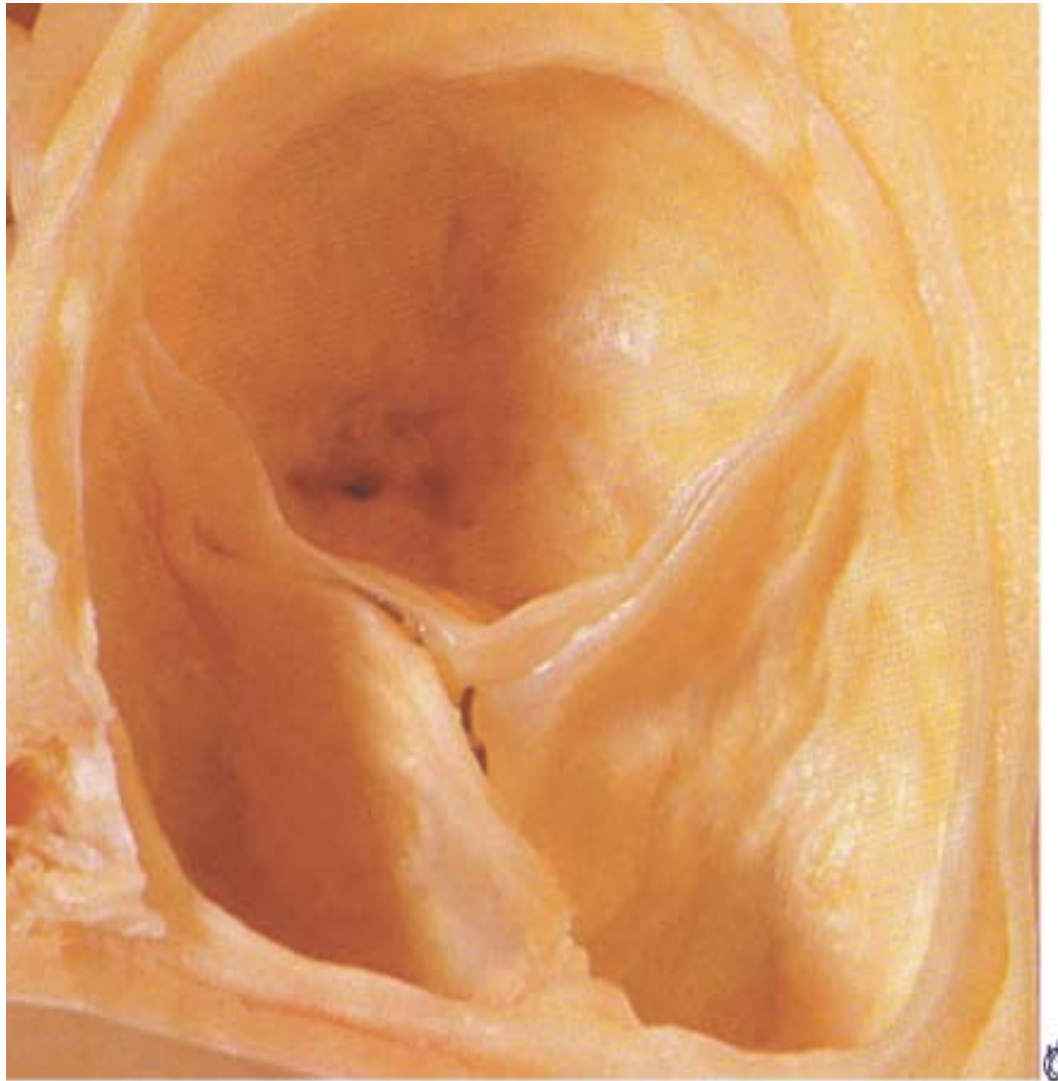
# LV Outflow obstruction

- Valvular Aortic Stenosis
- Supravalvular AS
- Subvalvular AS ( discrete membrane or fibromuscular tunnel).
- IHSS



## Aortic Stenosis

- - Bicuspid aortic valve syndrome (BAV)
  - Rheumatic
  - Atherosclerotic (“calcific”)



A

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B

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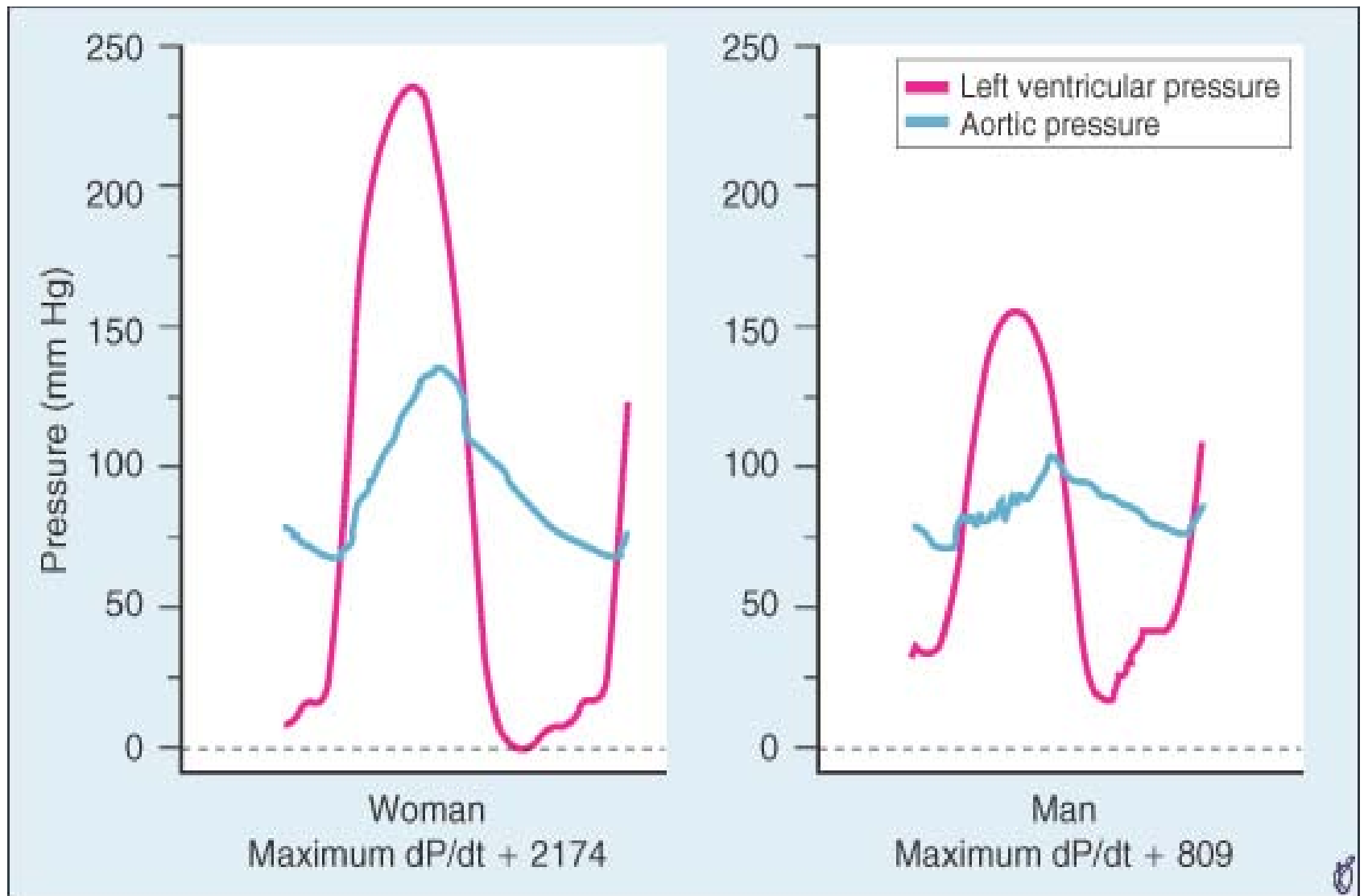
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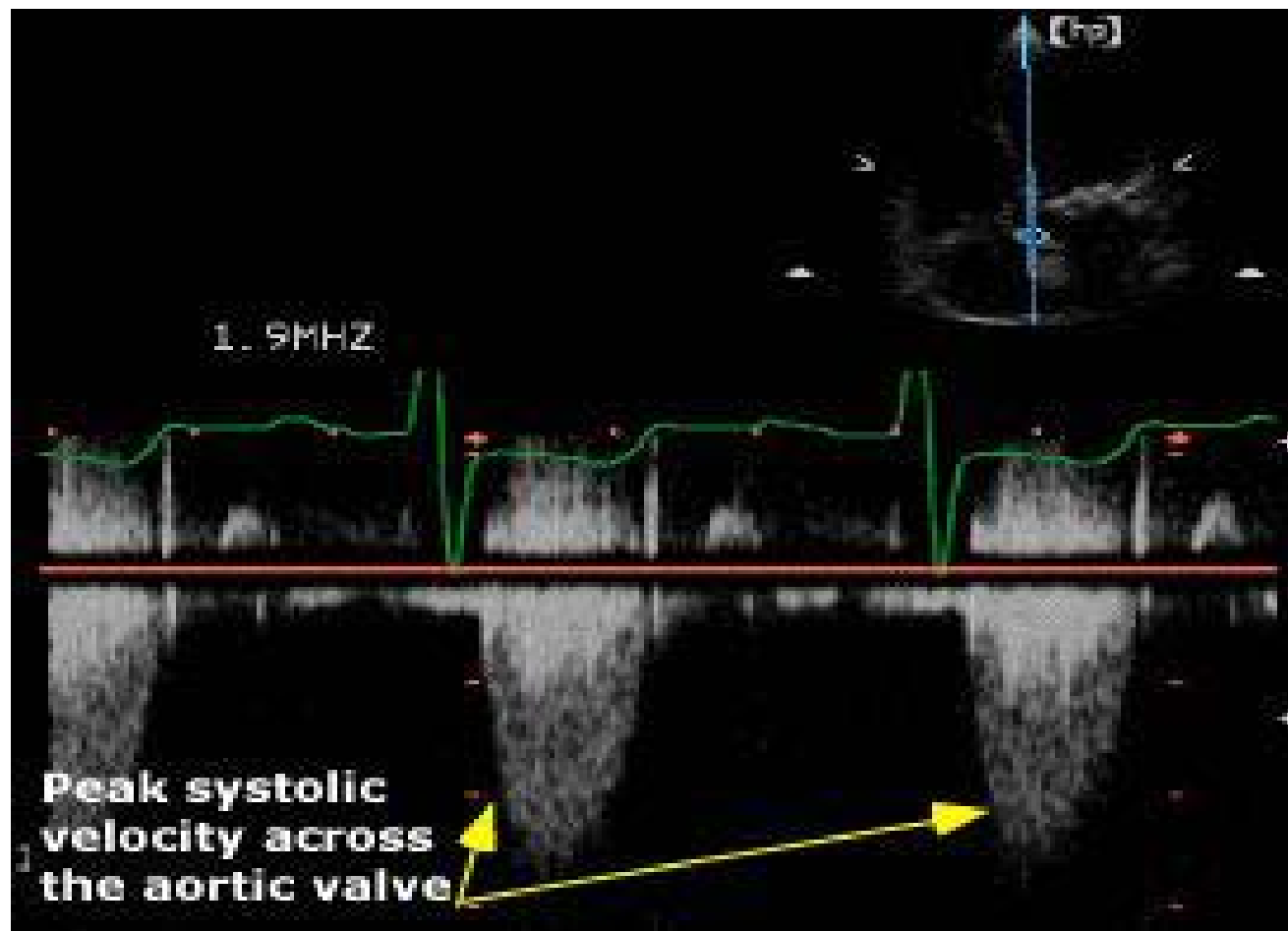
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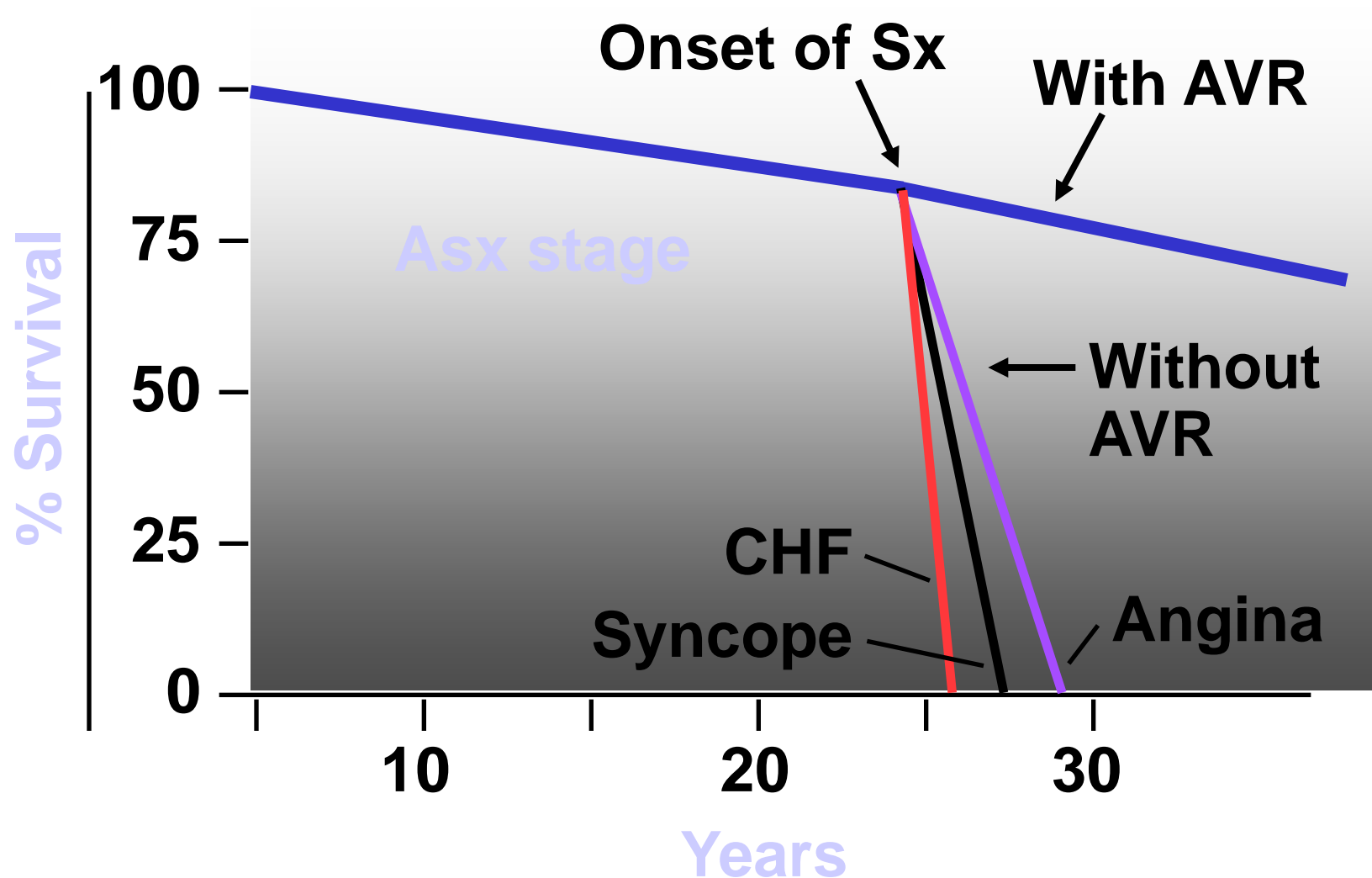




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# NATURAL HISTORY OF AORTIC STENOSIS



## AS: Echocardiographic Evaluation

- Aortic jet velocity
- Valve calcification
- Doppler AVA
- AR severity
- Mean transaortic gradient
- LVEF
- LVH
- ? etiology

# Bicuspid Aortic Valve Syndrome (BAV)

(Circulation 2002; 106: 900)

Incidence: 1-2% of population

? Autosomal dominant

Genetic disease of aortic root

Phenotype spectrum: unicuspid (severe) →

Bicuspid (moderate) → tricuspid (normal)

Associated genetic mal-developments:

Congenital: Coarctation, PDA, proximal coronary anomalies

Adult: Aortic dilation, aneurysm, dissection

## Bicuspid Aortic Valve (BAV)

(Circulation 2002; 106: 900)

- Commonest cause of AS: 15-65 years
- Death/morbidity incidence > all congenital lesions combined (>33%)
- Most will require intervention (surgery)
- Endocarditis incidence > 30%
- Screen first-degree relatives (echo)

## Aortic Stenosis

### Valve Area (cm<sup>2</sup>)

3-4	Normal
1.5-2.5	Systolic murmur (flow turbulence)
1-1.5	Trans-valvular gradient (resistance to flow)
0.75-1.0	Symptoms
<0.75 <0.5cm <sup>2</sup> /M <sup>2</sup>	Critical AS

# Atherosclerotic AS: Pathology & Risk

(Am Heart J 2004; 147: 761)

## Pathology:

Lipid core

Macrophages, foam cells

↑LDL-C, Lp (a), matrix metalloproteins

## Risk factors (after correcting for CAD):

Older age

Male gender

HTN, DM, smoking

Serum lipid levels (TC / HDL ratio)



# Metabolic syndrome and AS

- JACC: June 6, 2006
- Series of 106 patients with AS
- Progression of AS by Doppler was 2X as fast and the event free survival was markedly lower among patients with MS
- Mechanism possibly  $\uparrow$  LDL,  $\downarrow$  HDL and inflammatory components of MS

# Hypertension and AS

- JACC, June 6, 2000
- Experimental study with rabbits
- Rabbits made hypertensive by kidney clamping compared with controls.
- Aortic valve area was ↓ by 14% in 4 mo.  
In Htn animals and valve was thicker



## Atherosclerotic Aortic Stenosis: Effect of Statins

(Circulation 2001; 104: 2205)

N= 174

Age: 68 yrs

T= 21 months

	<u>Statins</u>	<u>No Statins</u>
Annual AVA progression	0.06 cms <sup>2</sup>	0.11 cms <sup>2</sup>

? Atherosclerotic etiology for calcific AS

To date effects of statins on progression of AS is unclear.

# Physical exam in AS

- Arterial pulse rises slowly, is small and sustained
- In severe AS systolic BP and pulse pressure are usually reduced.
- SBP may be higher in the elderly but rarely exceeds 200 mm Hg
- Cardiac impulse is sustained and may become laterally displaced if CHF occurs.\*

# Auscultation in AS

- Loud systolic murmur, late peaking in severe AS, heard best at upper R para sternal border with transmission to carotids and apex.
- Systolic murmurs ending in mid systole are rarely due to severe AS.
- S2 usually single or paradoxically split with LV dysfunction or LBBB
- Systolic ejection sound may be heard in children or young adults.

# ECG in AS

- LVH found in 85% of severe AS
- LVH without high voltage may be seen, particularly in COPD or obesity
- Pseudoinfarction pattern with poor R wave progression
- ↑ LA in 80% of severe AS
- Calcium in conduction system may cause various conduction abnormalities.

## Aortic Stenosis: Clinical Presentation

- Angina

↑ MVO<sub>2</sub> from ↑LV mass, ↑ LV systolic pressure

↓coronary flow from intramyocardial compression of coronary arteries, ↓ coronary reserve

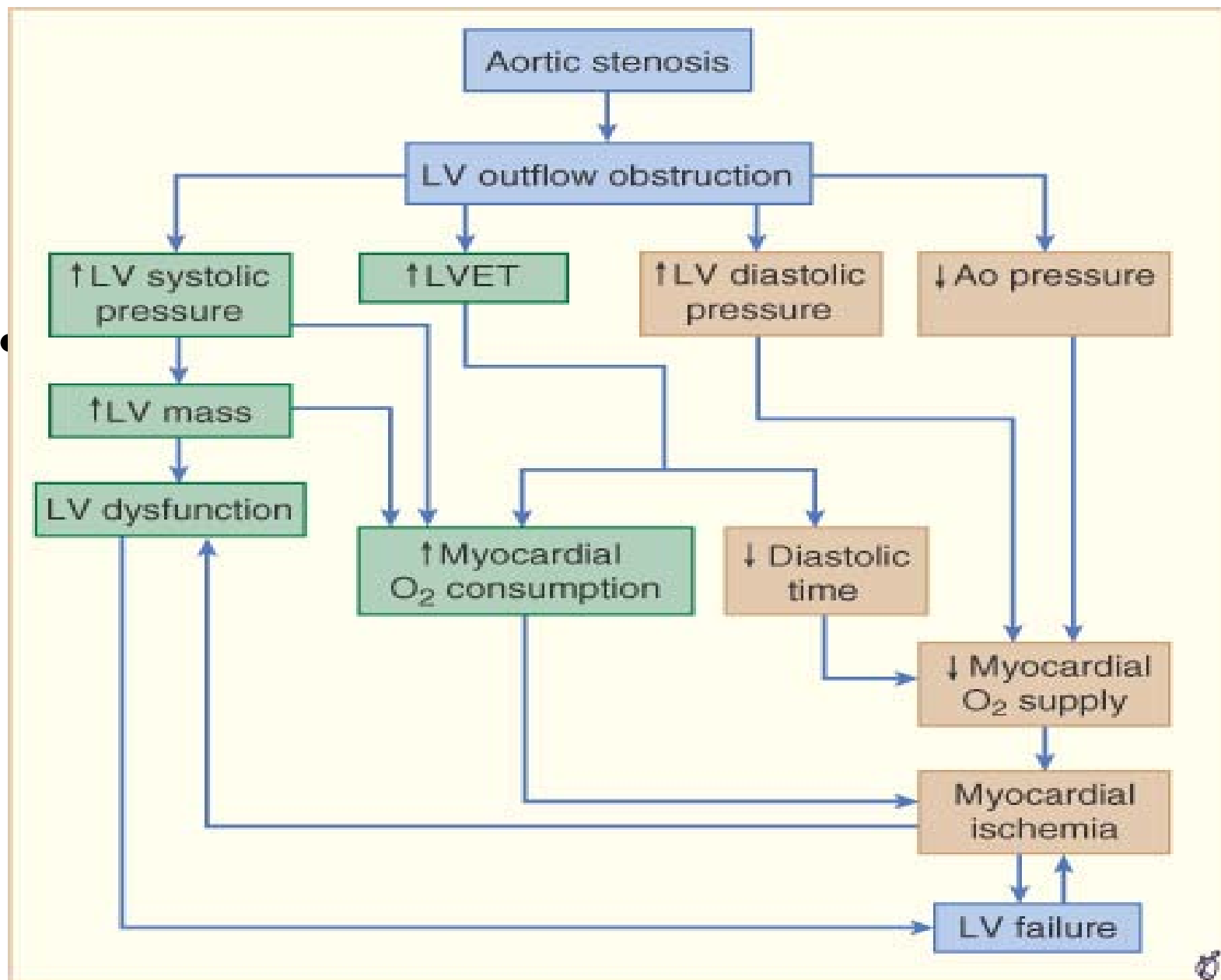
- Syncope

Exercise, from vasodilation with fixed CO

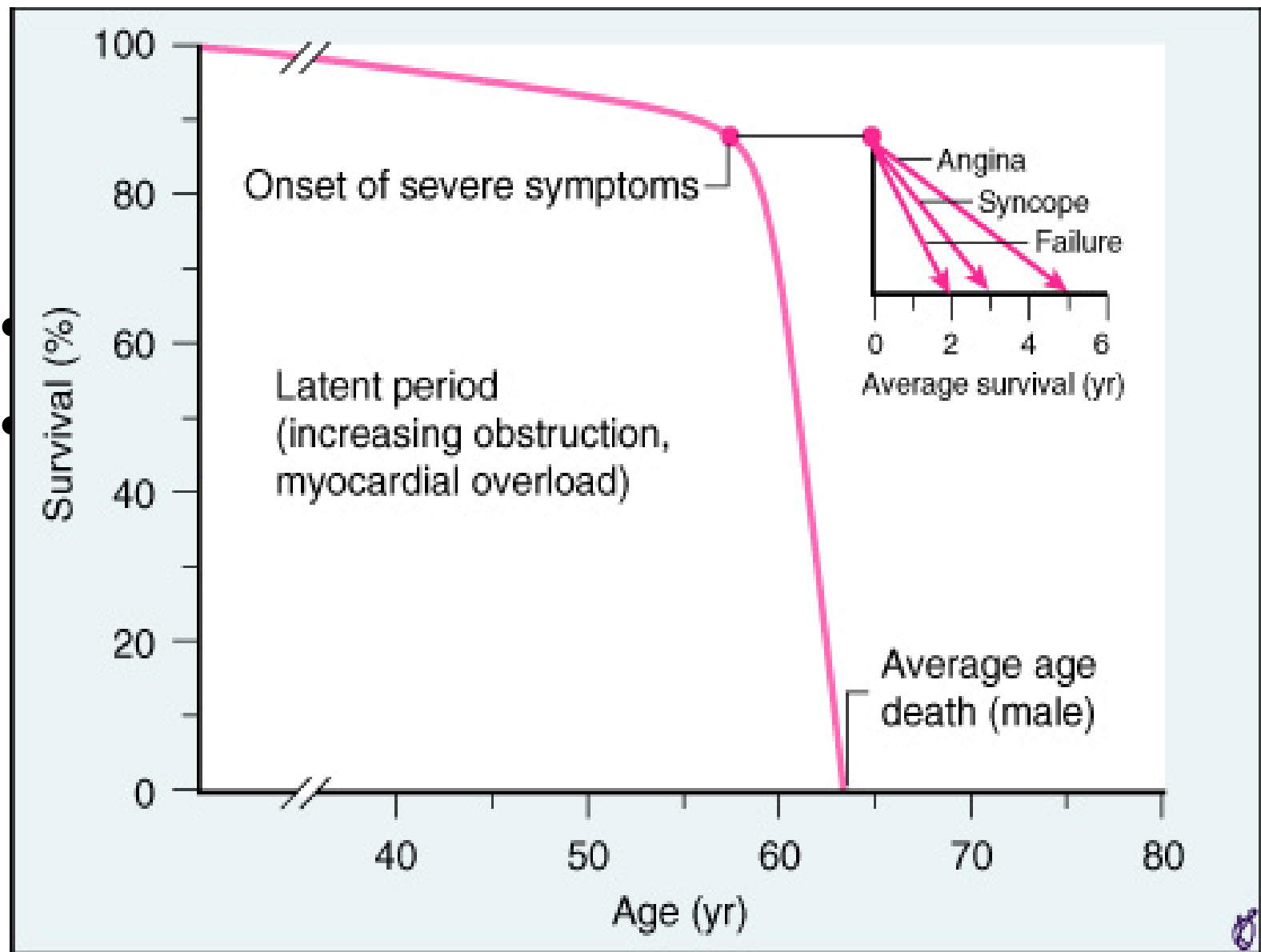
Rest, from transient VT, AF, AV block

- HF

- GI bleed, from GI AV-malformations (Heydes syndrome: Ann Thorac Surg 1987;44: 514)







# Syncope in AS

- Due to reduced cerebral perfusion during exertion when systemic vasodilatation occurs with fixed cardiac output.
- Malfunctioning baroreceptor mechanism with vasodepression due to  $\uparrow$  LV systolic BP during exercise.
- Arrhythmias may cause syncope at rest.

## Aortic Stenosis: Suggested Grading

	<u>AVA</u>	<u>AVA Index</u>
Mild	>1.5	> 0.9
Moderate	0.8-1.1	
Severe	<0.75 or ( V max > 4m/sec )	

## Aortic Stenosis: LVH

### LVH:

- Maintain normal wall stress
- Generate LV gradient to maintain stroke volume
- Structural alterations → ↓ myocardial compliance
- ↓ myocardial relaxation → ↑ resistance to filling

### Massive LVH:

- Mobilize preload reserve → LV dilation (Starling)
- Preload reserve depleted → ↓ LV systolic function
- ↓ coronary flow per 100 gm LV mass

## Aortic Stenosis: (Un) Natural History

(Davies, SW. Eur Heart J 1991; 12: 10)

N=65

T= 7 years (1-17 yrs)

Mean  $\uparrow$  in gradient: 6.5 mm Hg/year

10-year change (n=60): 10 mm Hg  $\rightarrow$  52 mm Hg

More rapid progression:

Calcification; associated AR

## Asymptomatic AS: Sudden Death

(Tajik, A. JACC 1990; 15: 1012)

- Significant risk for CV events in 2 years
- Low risk for sudden death as long as asymptomatic
- Medical management until symptomatic
- Doppler max. flow velocity  $> 4$  m/sec predictive for cardiac events

# Clinical manifestations of AS

- Dyspnea and CHF
- Dizziness and syncope
- Angina
- Endocarditis
- Bleeding tendency
- CAD

## Asymptomatic AS: Hemodynamic Progression

(Otto, C: Circulation 1997; 95: 2262)

↑ Jet velocity: 0.3 m/sec/year

↑ Mean gradient: 7 mm Hg/year

↓ AVA: 0.1 cms<sup>2</sup>/ year



# Bleeding tendency in AS

- Increased risk in AS
- GI bleeding attributed to angiodysplasia
- Acquired von Willebrand syndrome ( 60-90% of patients with severe AS ).Due to turbulent flow through the narrowed valve.
- Pts with AS treated with antiplatelet drugs may have increased bleeding.
- Increased bleeding with non cardiac surgery.
- Bleeding tendency improves with AVR

## Severe AS: Valve Calcification

(Hurst, W: The Heart, page 1672)

“Calcium in the aortic valve is the hallmark of AS in adults 40-45 years of age. In patients aged 45 years or above, the diagnosis of severe AS is doubtful if there is no calcium in the aortic valve.”

## Asymptomatic Severe AS: Sudden Death

Consider AVR with:

- Aortic jet velocity  $> 4\text{m/s}$
- Moderate/severe calcification
- Echo “energy loss index”  $\leq 0.52 \text{ cm}^2/\text{m}^2$  (Circulation 2000; 101: 765)
- Change in AVA by echo during a cardiac cycle (Circulation 2000; 101: 1947)

Absolute mean pressure gradient does NOT determine timing for AVR

# Consider surgery in asymptomatic severe AS

- Extensive AV calcium
- Rapid aortic jet velocity progression
- Concomitant CAD
- LV systolic dysfunction
- Elevated BNP levels
- Very abnormal exercise test.
- Very small valve area
- Before major non cardiac surgery

## Aortic Stenosis: Indications for Cath

- Before surgery in all patients  $> 35$  years
- Before surgery in all patients  $< 35$  years if:  
CAD, LV dysfunction,  $\geq 2$  risk factors for CAD
- Clinical (symptoms)/ Echo discrepancy

## Aortic Stenosis: Medical Management

- Streptococcal prophylaxis
- IE prophylaxis
- Reversal of remodeling
- Anticoagulation for AF
- Rate control for AF
- Gentle diuresis, digoxin 0.125 mg /day for HF

## Severe AS with HF: Medical Management

(NEJM 2003; 348: 18)

N= 25      Mean AVA: 0.6 cms<sup>2</sup>      Mean LVEF: 0.21  
Mean Nitroprusside: 103 (6 hrs) → 128 mcg/min (24 hrs)

	<u>Basal</u>	<u>6 hrs</u>	<u>24 hrs</u>
CI	1.60	2.22	2.52

- Individualize therapy
- Safe with full hemodynamic monitoring in ICU
- Bridge to AVR

## Aortic Stenosis: Indications for Surgery

### Symptomatic:

- Jet velocity, AVA, AR criteria
- In general AS with low EF will improve post OP

### Asymptomatic:

- Aortic jet velocity  $> 4$  m/s
- Moderate/severe calcification
- Other echocardiographic criteria

Absolute pressure gradient does  
NOT determine timing for AVR



## Aortic Stenosis: Balloon Valvuloplasty

Hospital mortality: 7- 13%

Hospital complications: 25%

6-month restenosis: 65-77%

6-month mortality: 15-22%

## Aortic Stenosis: Balloon Valvuloplasty

Possible indications:

- Bridge to surgery in unstable patients
- Palliation in inoperable patients

NOT a substitute for AVR in adults

## AVR for AS: Hemodynamic Course

(Morrow, A. Circulation 1980; 61: 814)

N = 42

Starr-Edwards: 72%

	<u>Pre-op</u>	<u>6 months</u>
AVA	0.56	1.05
Peak gradient	81	16
LVEDP	18	14
PCWP	13	10
PAS	33	28

## AVR for AS: Echocardiographic Course

(Morrow, A. Circulation 1980; 61: 814)

Pre-op LV dilatation (n=11)

	<u>Pre-op</u>	<u>6 months</u>
LV mass	578	420 *
LV wall thickness	15.1	13.6 *
EDD	60.7	54.8 *
ESD	42.9	38 *
Fractional %	30.2	31

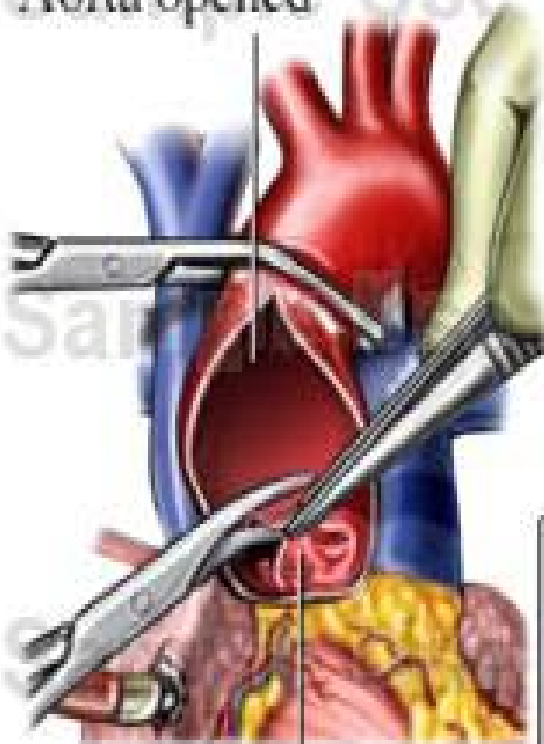
## Aortic Valve Disease: Choice of Prosthesis for AVR

(Hammermeister, K. JACC 2000; 36: 1152)

### At 15 years follow-up:

- All-cause/ valve related mortality is lower for mechanical (Biork Shiley) vs bioprosthetic (Hancock) valve (66% vs 79%)
- Primary valve failure (26% vs 0%) and re-operation rate (29% vs 10%) more with bioprosthetic primarily in age < 65 years; no difference in failure rates at age > 65 years
- Bleeding more frequently with mechanical prosthesis
- Similar incidence of valve thrombosis, thromboembolism, and endocarditis
- Most common mechanical valve is ST.Jude

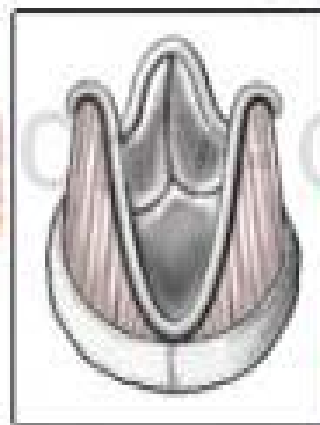
Aorta opened



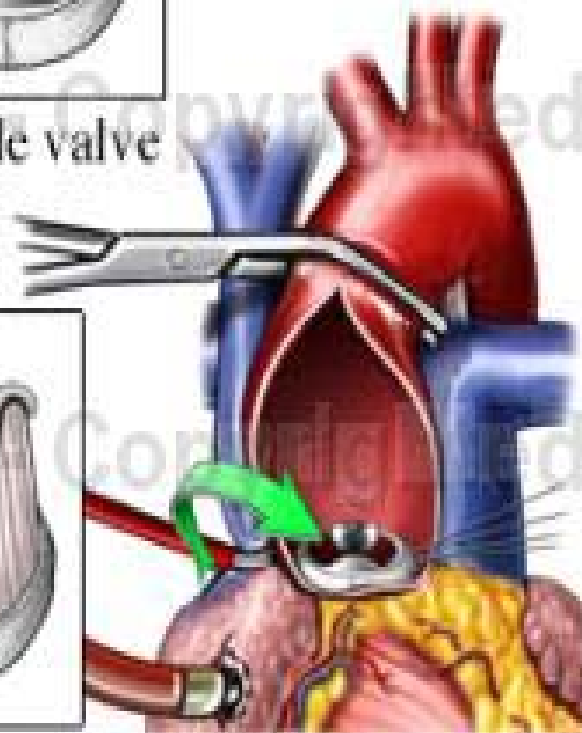
Diseased  
aortic valve



St. Jude valve



Porcine valve



## Low Gradient AS

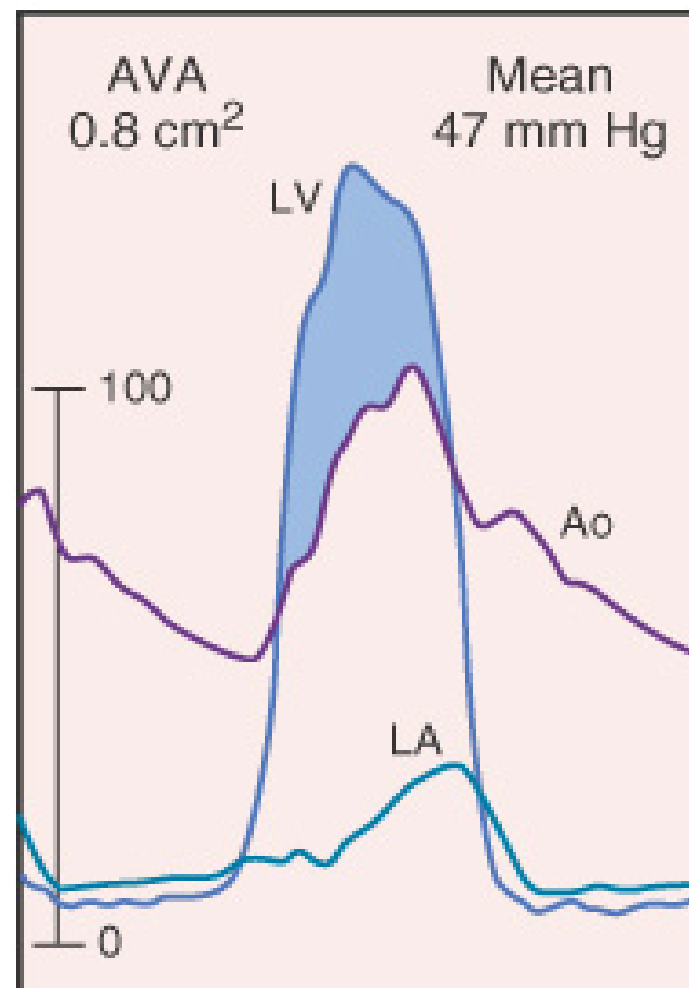
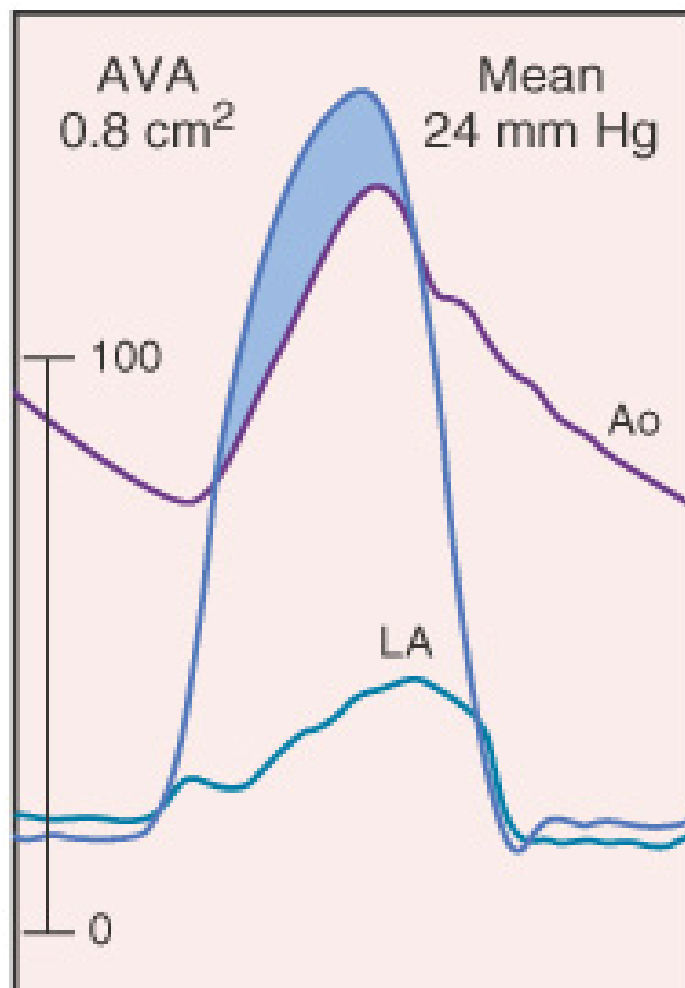
(Circulation 1994; 89: 827)

True stenosis: Severe LV dysfunction is secondary to and because of the critical valve narrowing

Pseudostenosis: Primary severe myocardial dysfunction is unrelated to the valve lesion

Miscalculation of the valve narrowing to be severe because of the limitations of applying the valve area equations to low flow rate conditions

A



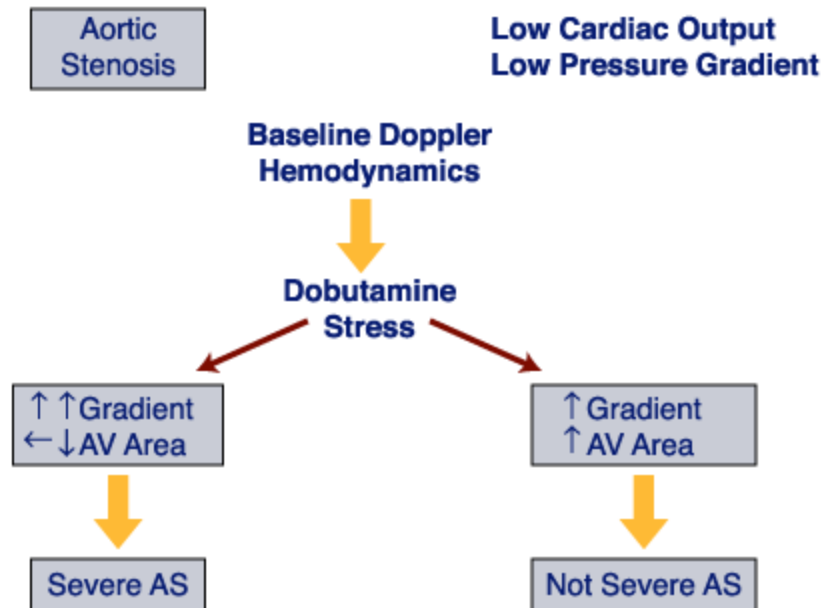


## Aortic Stenosis and Dobutamine Stress in Echocardiography

Size: 13 KB File Type: GIF

[Talk Back](#)

## Aortic Stenosis and Dobutamine Stress in Echocardiography

**Source**

Clinical images provided by the American College of Cardiology Foundation



## Low Gradient AS: Dobutamine Stress Test

(Grayburn, PA. JACC 1995; 75: 191)

Dobutamine: 5 mcg/kg/min → 20 mcg/kg/min

Valve resistance = Mean gradient / stroke volume

True Stenosis: No change in calculated AVA; increase in valve resistance

Pseudostenosis: Increase in calculated AVA (0.8-1.1 cms<sup>2</sup>); decrease in valve resistance

Improve with AVR:

- True stenosis

Continue Medical Rx

- Pseudostenosis

## Low Gradient AS: AVR

(Tajik, AJ. Circulation 2000; 101: 1940)

N=52

Simultaneous CABG: 63%

Early mortality: 21%

Total late mortality: 40%

Improved post-op LVEF: 74%

Post-op mortality: Advanced age; small prosthesis size

## Low Gradient AS: AVR

(Pereira, JJ. JACC 2002; 39: 1356)

AVA < 0.75 cms<sup>2</sup> (true AS)

LVEF ≤ 0.35

Gradient: < 30 mm Hg

### AVR

N=68

### Medical Rx

N=89

1-year survival (%)

82

41

4-year survival (%)

78

15

Determinants of survival: AVR, ↑age, ↑creatinine

# Aortic Valve Disease: Choice of Prosthesis for AVR

(Hammermeister, K. JACC 2000; 36: 1152)

## Bioprosthesis:

- Age > 70 years
- Cannot or will not take coumadin

## Mechanical Prosthesis:

- Long life span (Age < 70 years)
- Pre-existing need for anticoagulation
- Another mechanical prosthesis in place

## Aortic Valve Disease: Ross Procedure

(Ross, D. Lancet 1967; 2: 956)

AVR with pulmonary autograft +  
Right-sided reconstruction with aortic/pulmonary homograft

- No primary degeneration (long term viability)
- No anticoagulation
- Optimal hemodynamics
- Autograft grows with patient (regeneration capacity)
- Possible resistance to infection
- Lack of valve noise

# Aortic Valve Disease: Ross Procedure

(Ross, D. Eur J Cardiothorac Surg 1992; 6: 113)

N= 339                      1969-1991              T = up to 24 years

Hospital mortality: 7.4% (n=1 since 1974)

Late mortality: 11.2% (39% from re-operation)

Re-operation (AR): 11.2%

IE: 3.2%

Anticoagulation: 0%

Emboli: 0%

Actuarial analysis at 20 years:

Survival: 80%

Freedom from re-operation: 85%

# AS and CAD

- Coexisting CAD (  $>75\%$  stenosis ) occurs in approximately 40% of patients with AS
- If AS is severe- AVR plus CABG
- Moderate AS plus CAD –RX evolving, may consider initial PCI with subsequent AVR if needed.\*
- \* J.Invasive Card.Vol 16/No.12 ,12/2004





## Should CABG pts with mild to moderate AS undergo AVR ?

- AVR for all ages if valve gradient  $> 50$ .
- Under age 70 if gradient  $> 30$ , consider AVR ( assuming  $\uparrow$  of 5 mm/yr ).
- Over age 70, CABG alone usually indicated.
- Co morbidities and pt preference still important in making this difficult decision.

# Predictors of poor outcome after AVR

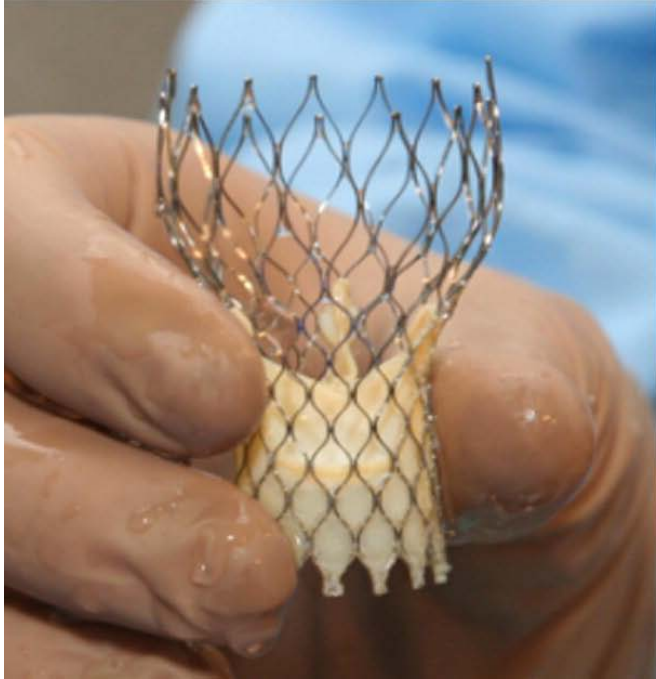
- Advanced age
- Female
- Emergency surgery
- CAD, or previous CABG
- HTN
- HX CHF or severe LV dysfunction
- Atrial fibrillation
- Concurrent MVR
- Renal failure

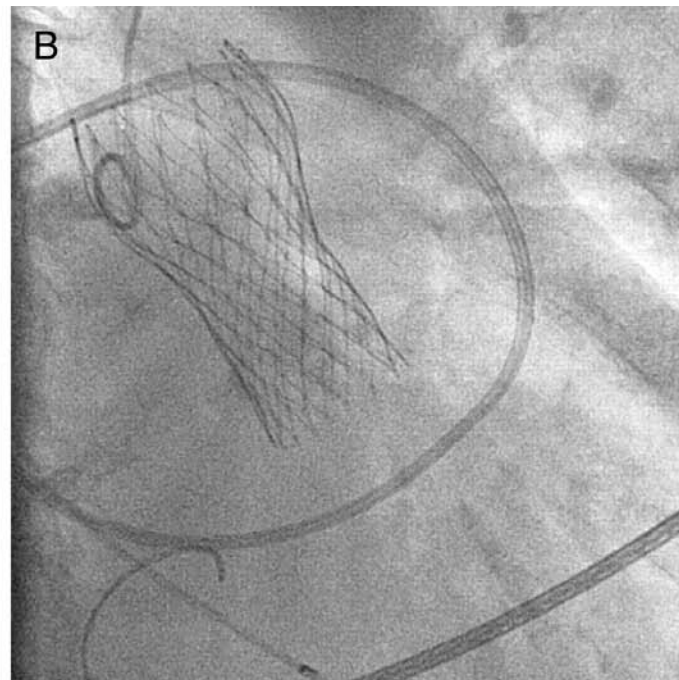
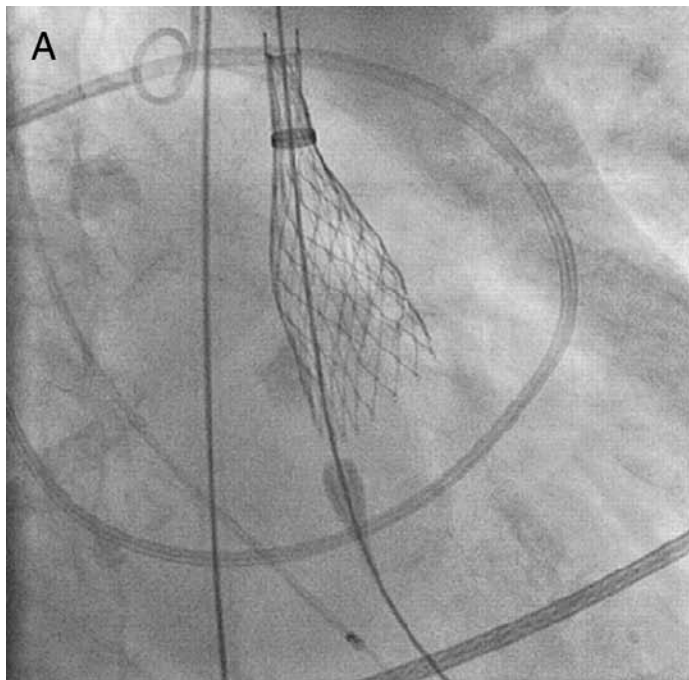
# Percutaneous AV replacement

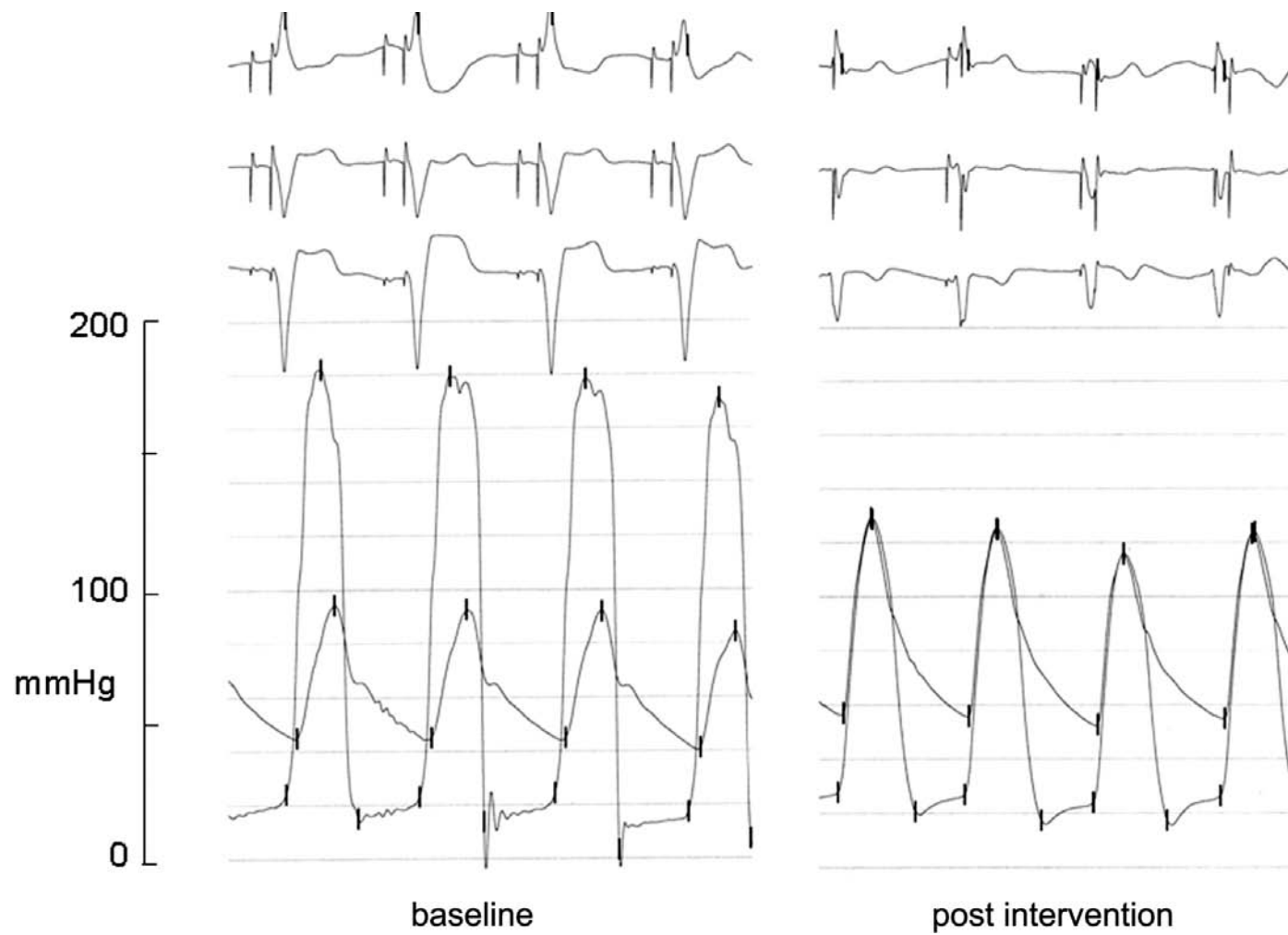
Experimental procedure for patients in whom standard AVR can not be done.

Evolving technology where prosthetic valve is mounted on a balloon device and then seated in AV area. Two methods currently used, transfemoral and apical.

Used for very elderly patients with multiple co-morbidities.







# Asymptomatic severe AS

- Usually surgery not indicated.
- Stress test may be helpful: if exercise capacity good and no symptoms during stress, no decrease in ejection fraction or drop in BP, outlook probably good.