

Ascending Aortic Surgery:

How, When and For Whom?

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Disclosure



- Nothing relevant to disclose.

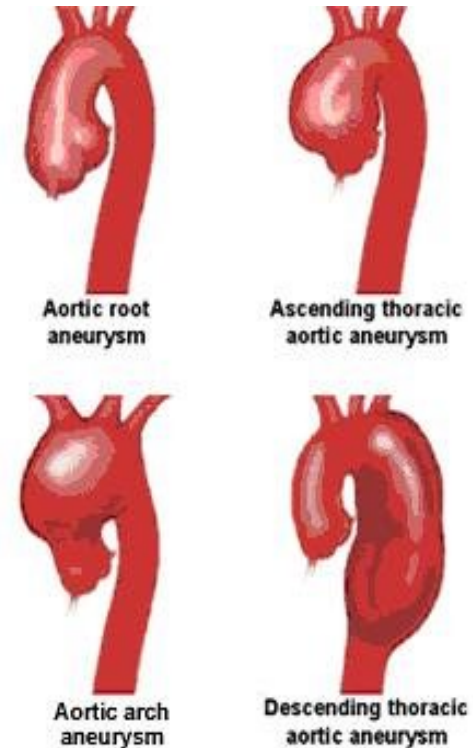
Ascending Aortic Aneurysm

- Anatomy & Natural History
- Histopathology & Medical Tx Options
- When should we operate?
- Surgical Treatment Options

Thoracic Aortic Aneurysm

ANATOMY & NATURAL HISTORY

- Ascending Aorta 51%
- Aortic Arch 11%
- Descending Aorta 38%
- dissection 53%, atherosclerosis 29%, aortitis 8%, cystic medial necrosis 6%
- 25% concomitant abdo aneurysm



Thoracic Aortic Aneurysm ANATOMY & NATURAL HISTORY

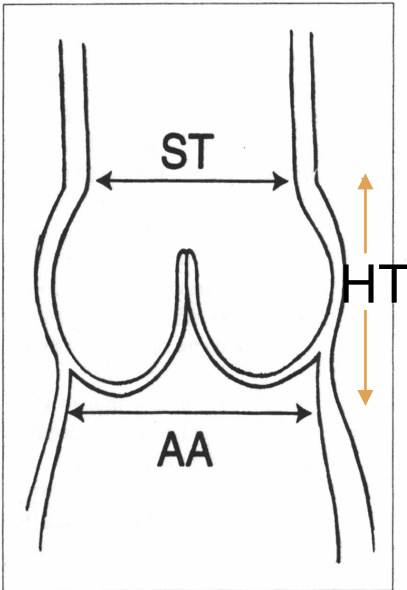
- Over 30 years: 74% of untreated thoracic aneurysms ruptured, 94% died
- 95% of dissections vs. 51% of non-dissections ruptured
- 5-year risk depends on size:
 - <1% for diameter < 4 cm
 - 16% for diameter 4 - 5.9 cm
 - 31% for diameter > 6 cm

Bickerstaff et al.
Surgery 1982; 92:1103

Thoracic Aortic Disease

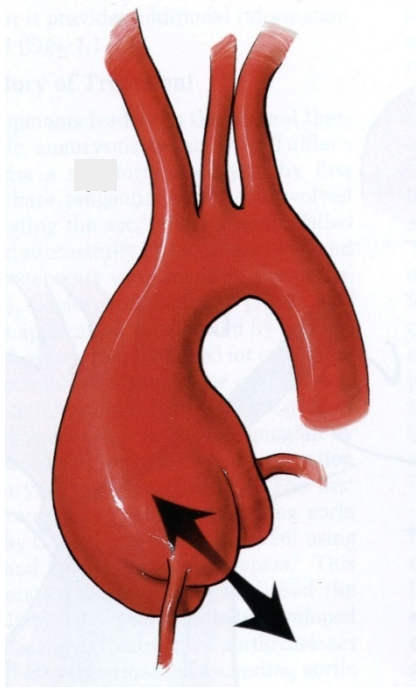
ASCENDING AORTA

- Proximal Sinus Portion (Aortic Root):
 - Aortic annulus, sinuses of Valsalva, aortic valve, coronary ostia
- Distal Tubular Portion:
 - Sinotubular junction to innominate artery
 - Elastic reservoir- stores energy during systole, released during diastole to enhance flow
- Aneurysms:
 - Ascending only- ↑ST but AA & HT normal
 - Replace Sinuses- ↑HT >> AA
 - Annuloaortic Ectasia- ↑ST, ↑HT, ↑AA



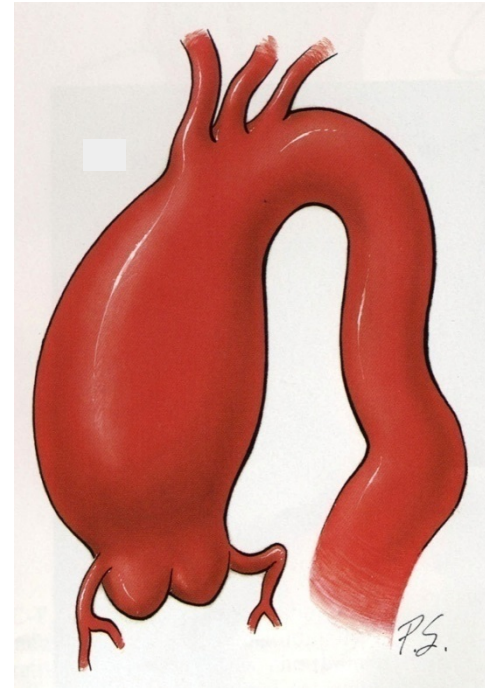
Thoracic Aortic Disease

ASCENDING AORTA



Annuloaortic Ectasia

↑ ST, ↑ AA, ↑ HT



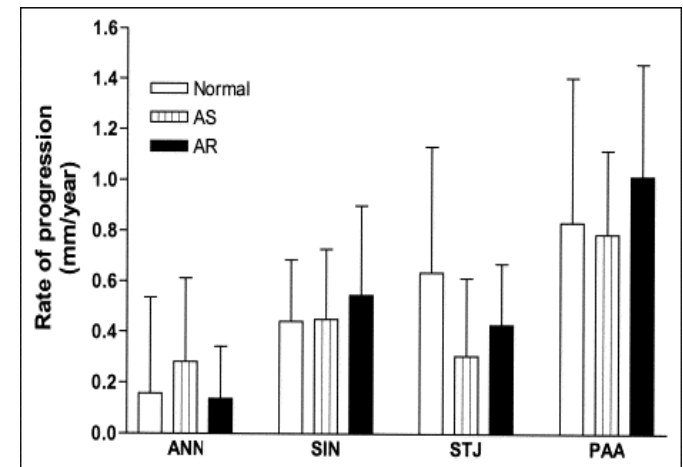
Ascd Ao Aneurysm

↑ ST, AA nl, HT nl

Bicuspid Valve Disease

AORTIC GROWTH RATE

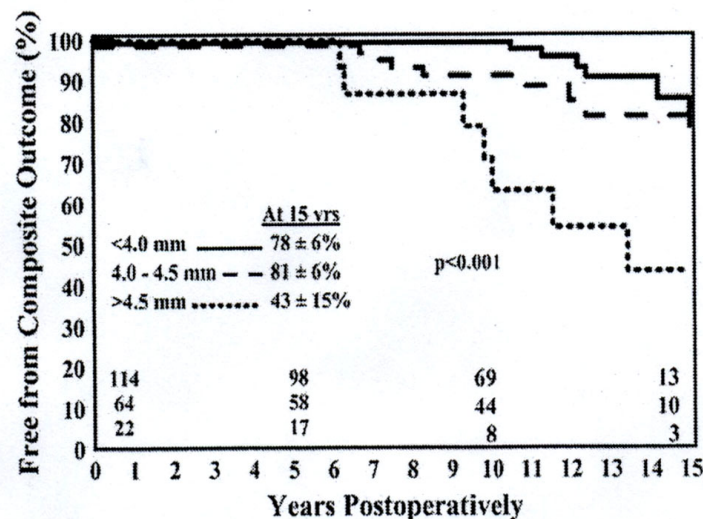
- Ferencik (U Mass) *Am J Cardiol* 2003 92:43
 - 68 pts Bicuspid AoV- n1 vs. AS vs. A1
 - Age 44 yo, F/U 47 mo, Serial Echo
 - Sinus of Valsalva: 0.5 mm/yr growth rate
 - St Junction: →0.5 mm/yr
 - Ascending Ao: 0.9 mm/yr
 - Mean gradient 18 26 mmHg, ↑A1 in 25%
- Cecconi (Italy) *Am J Cardiol* 2005; 95:292
 - ↑Growth Rate with ↑age (especially if > 40 yo)



Bicuspid Valve Disease

Aortic Complications after AVR

- Borger et al. (Toronto) *JTCVS* 2004; 128: 677
 - Bicuspid AVT (no Asc d Ao) in 201 patients: 1979-1993
 - Age: 56 ± 15 yrs, mean F/U 10 ± 4 yrs
 - <4.0 cm: 115 (58%) 4.0-4.4cm: 64 (32%)
 - 4.5-4.9 cm: 22 (11%) ≥ 5.0 cm: Asc d Ao replacement



- Ao ≥ 4.5 cm \rightarrow \downarrow late survival, \uparrow aortic complications

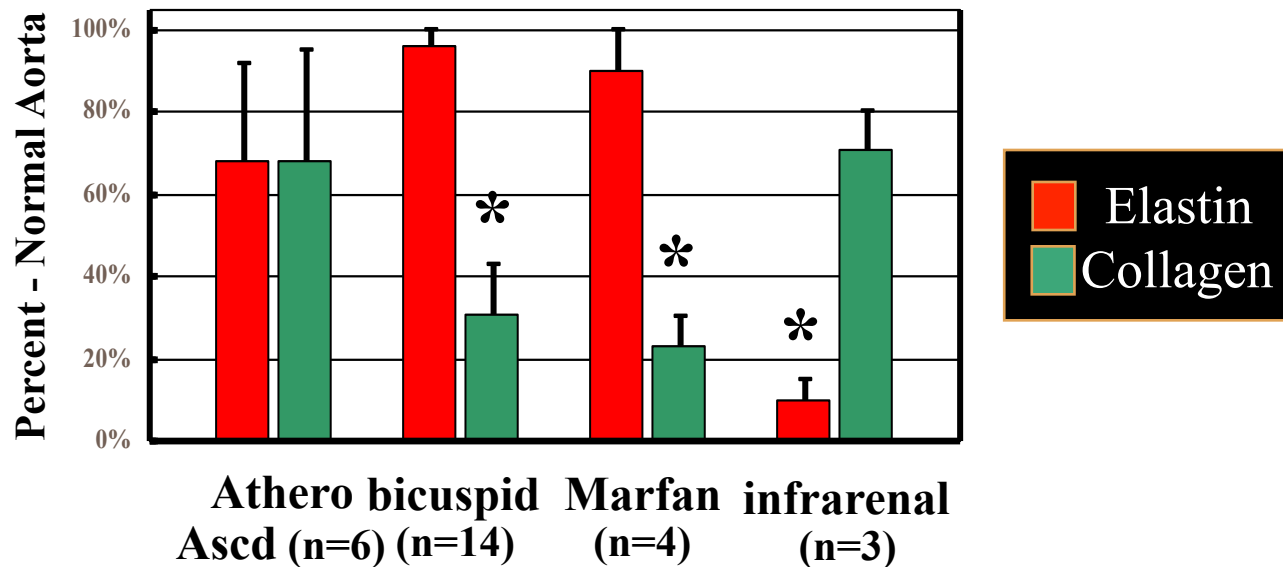
Thoracic Aortic Aneurysm

- Anatomy & natural history
- **Histopathology & medical tx options**
- When should we operate?
- Surgical treatment options

Cellular/Molecular Pathophysiology

HISTOPATHOLOGY - Asc d vs. Abdo Aneurysms

- Histopathology (*Circulation* 2000;102:II-400)
 - Infrarenal Aorta: intimal atherosclerosis, inflammation, destructive remodeling - elastic media
 - Ascending Aorta: non-inflammatory loss of smooth muscle cells, fragmentation - elastic fibers, mucoid degeneration

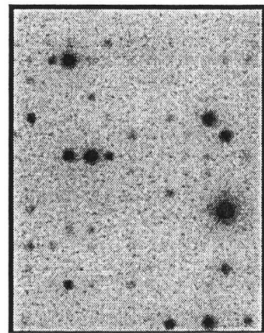


Cellular/Molecular Pathophysiology

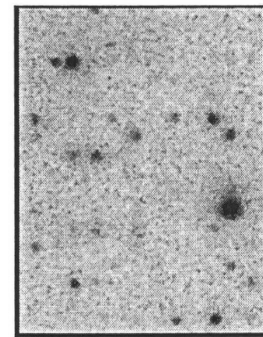
GENE EXPRESSION - Asc d vs. Abdo Aneurysms

- Differential Gene Expression (*JTCVS* 2003;126:344)
 - 1185 genes: cDNA microarray (*CLONTECH*), quantitative RT-PCR
 - Degenerative Asc d / Infrarenal AAA vs. nl asc d / abdo Ao

Normal Ascending Aorta



Ascending Aortic Aneurysm



↑ with AAA NOT Asc d
Apolipoprotein-E 15-fold
Interleukin-8 7-fold
- athero / inflammation

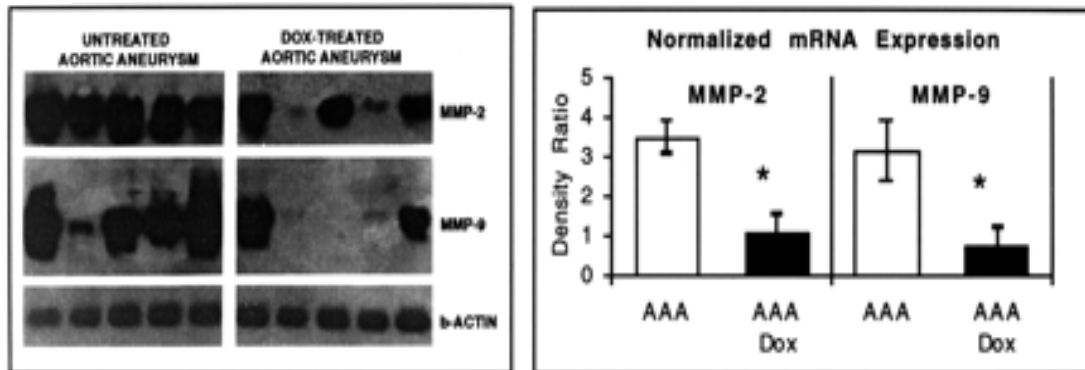
↑ with Asc d NOT AAA
Interleukin-1 β 15-fold
TNF- α 7-fold
- cell survival / apoptosis

↑ with AAA AND Asc d
MMP-9 Asc d: 9-fold
AAA: 86-fold
- elastin degradation

Cellular/Molecular Pathophysiology

Matrix Metalloproteinase

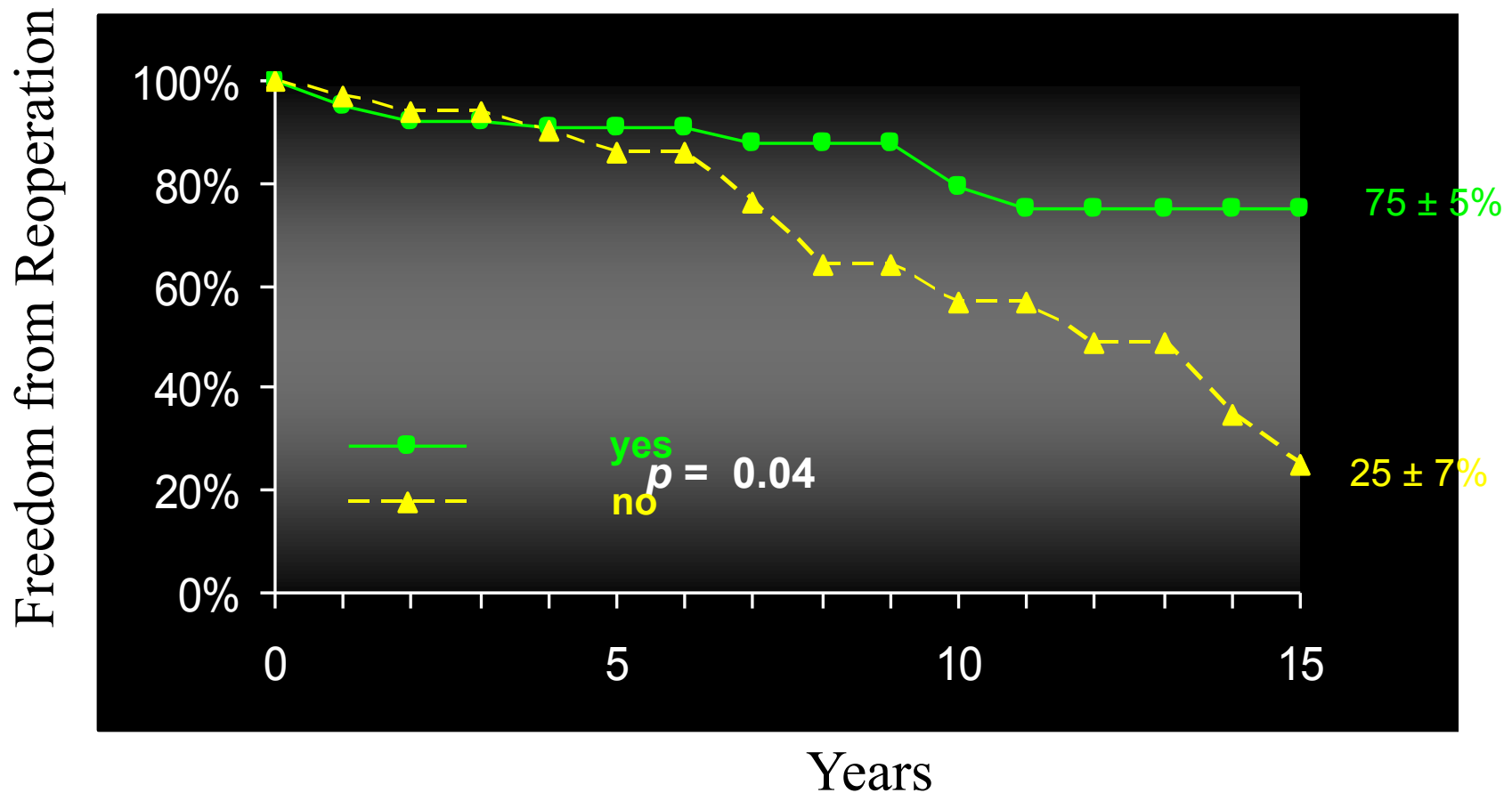
- MMPs: endopeptidases capable of degrading elastin & collagen (extracellular matrix) that maintain Ao integrity
 - MMP-2 – SMC, elastolytic properties
 - MMP-9 – macrophages, inflammatory, \uparrow in AAA
- Thompson (Wash U.) - Med Tx options for AAA
 - Doxycycline \downarrow MMP-2 & MMP-9, but high dose necessary
 - Gene-specific targets?



Impact of Late β -blocker Use

Late Reoperation after Type A Repair

- Impact of late β -blocker use (250 pts) – *Wash U. – J Clin HTN* 2013

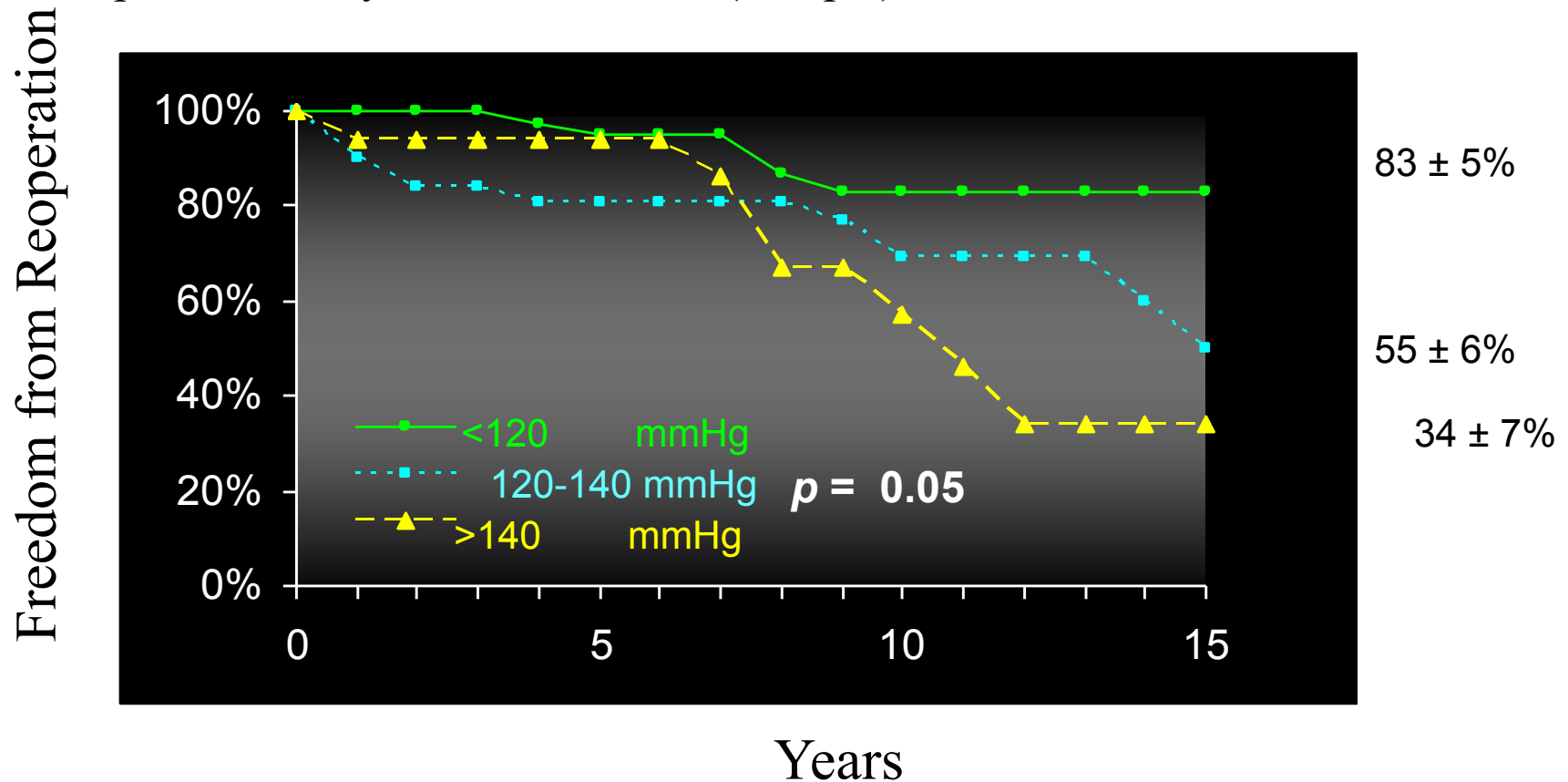


ATS 2007;83:2122

J Clin HTN 2013;15:63

Impact of Late BP Control Late Reoperation after Type A Repair

- Impact of late systolic BP control (250 pts) – *Wash U. – J Clin HTN 2013*



ATS 2007;83:2122

J Clin HTN 2013;15:63

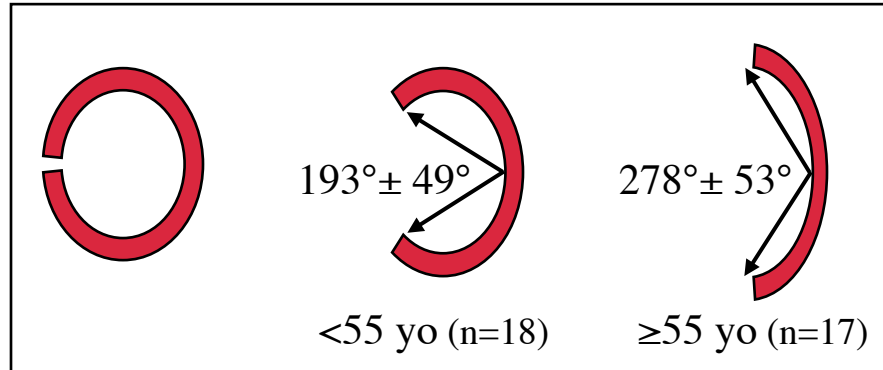
Thoracic Aortic Aneurysm

- Anatomy & natural history
- Histopathology & medical treatment options
- **When should we operate?**
- Surgical treatment options

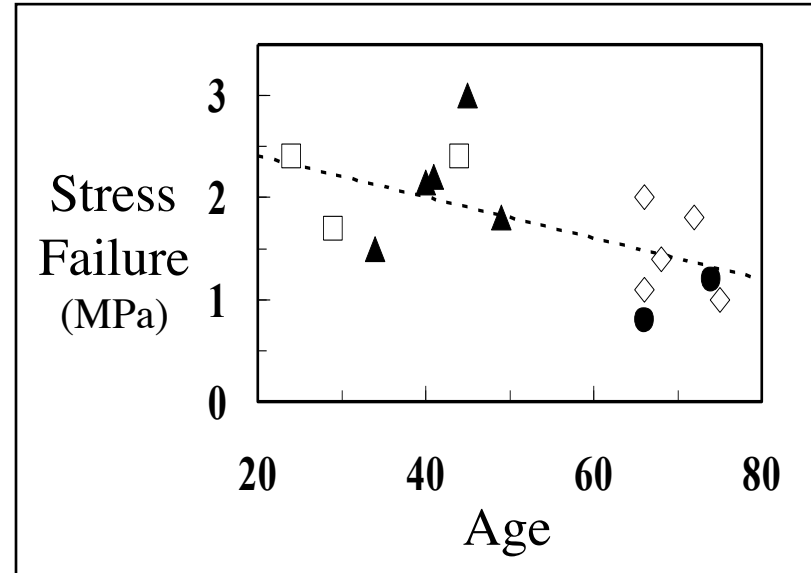
Mechanical Properties ASCENDING AORTIC ANEURYSMS

- Aortic tissue, 35 pts (Wash U. - *JTCVS* 2003;126:842)
 - Biaxial testing (force transducers) $\rightarrow \sigma = P \cdot r / 2h$
 - Circumferential wall stress: \uparrow SBP 26 mmHg $\approx \uparrow$ dia 1cm

OPENING ANGLE



UNIAXIAL STRENGTH



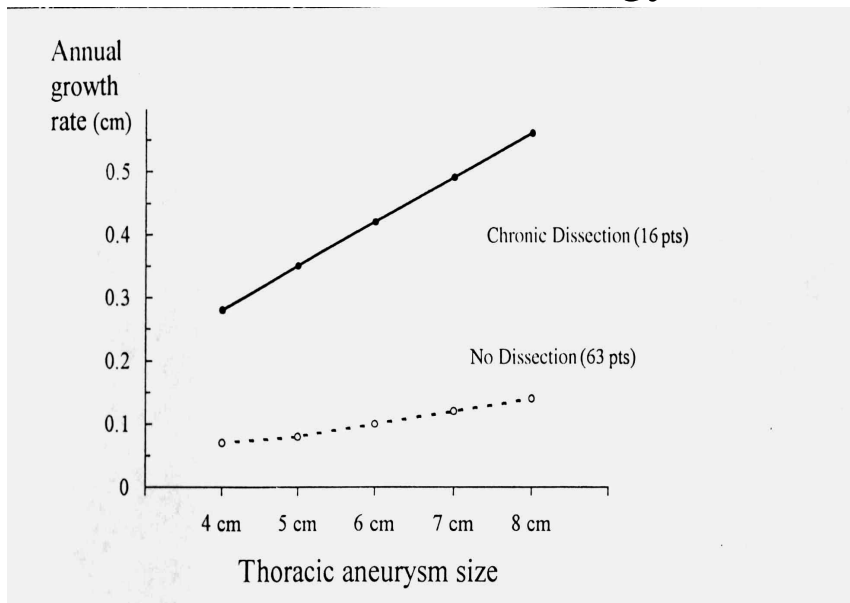
- OLDER PATIENTS:
 - \uparrow residual stress ($p < 0.01$)
 - \downarrow wall strength ($p < 0.01$)

Ascending Aorta & Root Aneurysms

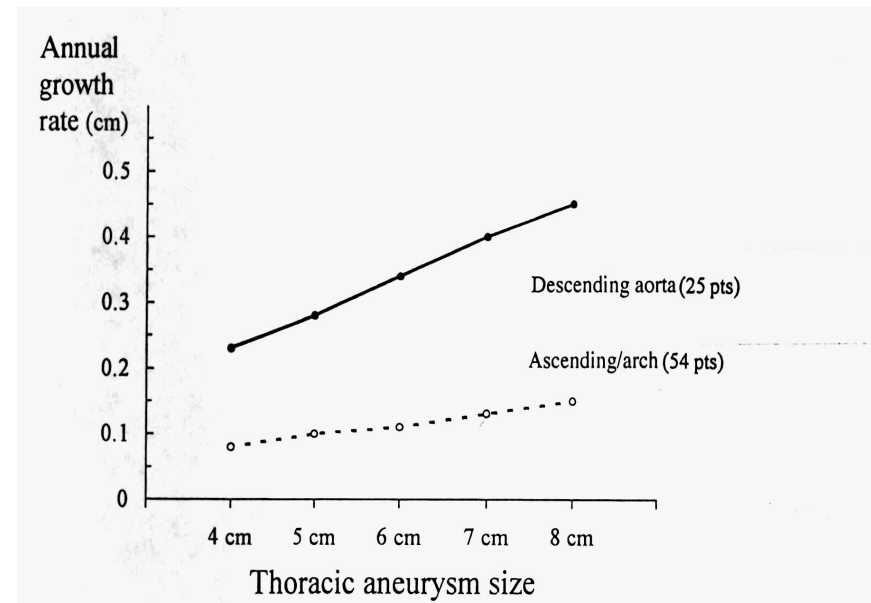
WHEN SHOULD WE OPERATE?

- Coady *et al.* - Yale (*JTCVS* 1997;113:476)

Growth Rate - Etiology



Growth Rate - Location



- Juvonen *et al.* - Mt Siani (*ATS* 1997;63:1533) - 102 pts (Descending Aneurysm)
 - aneurysm size, age, presence of non-specific pain, COPD

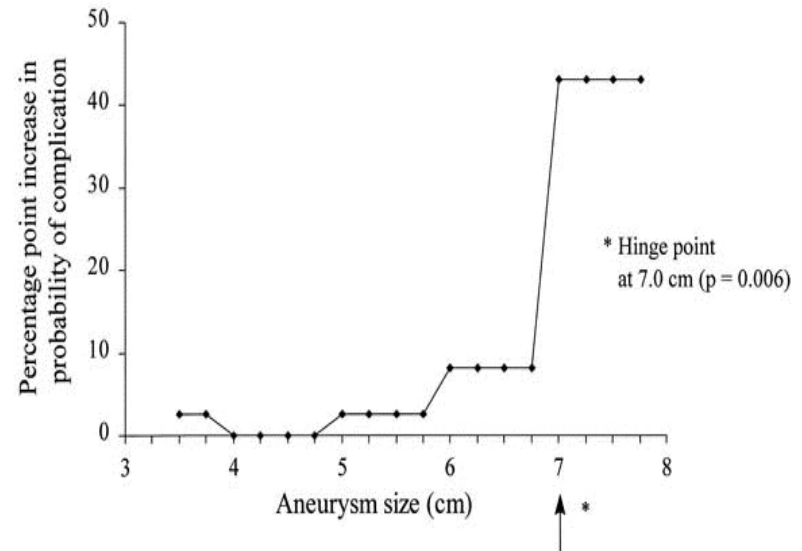
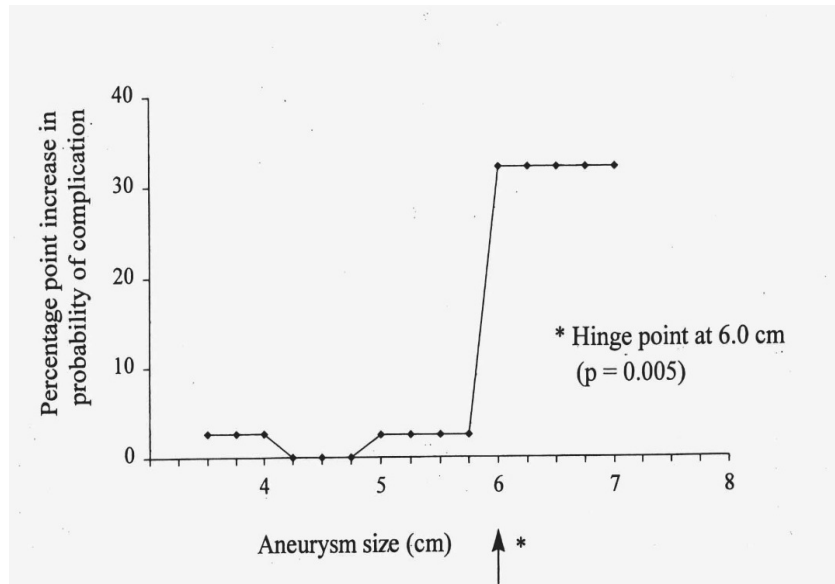
Rupture rate / year (λ):

$$\ln \lambda = -21.005 + 0.009(\text{age}) + 0.842(\text{pain}) + 1.282(\text{COPD}) + 0.643(\text{desc size}) + 0.405(\text{abdo size})$$

Ascending / Descending Aneurysms

WHEN SHOULD WE OPERATE?

- Effect of size on risk of complications
 - Ascd: Beyond 6 cm → ↑30% risk of rupture/dissection
 - Dsec: Beyond 7 cm → ↑40% risk of rupture/dissection



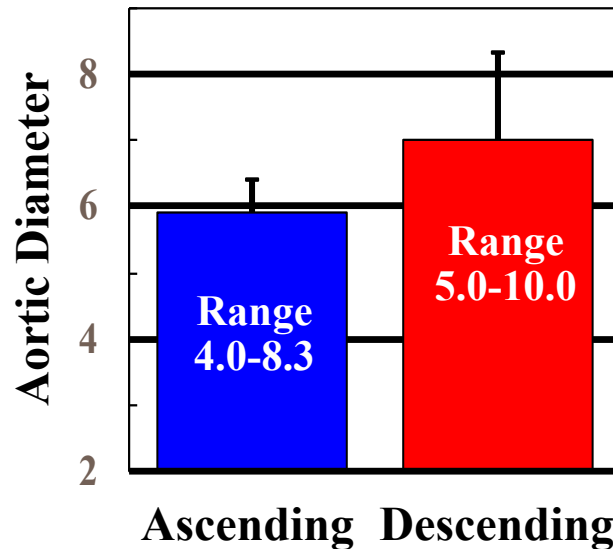
- Elective surgery at 5.5 cm Ascd, 6.5 Desc - before the “hinge point”

Ascending / Descending Aneurysms

WHEN SHOULD WE OPERATE?

- Complications can occur at smaller diameters

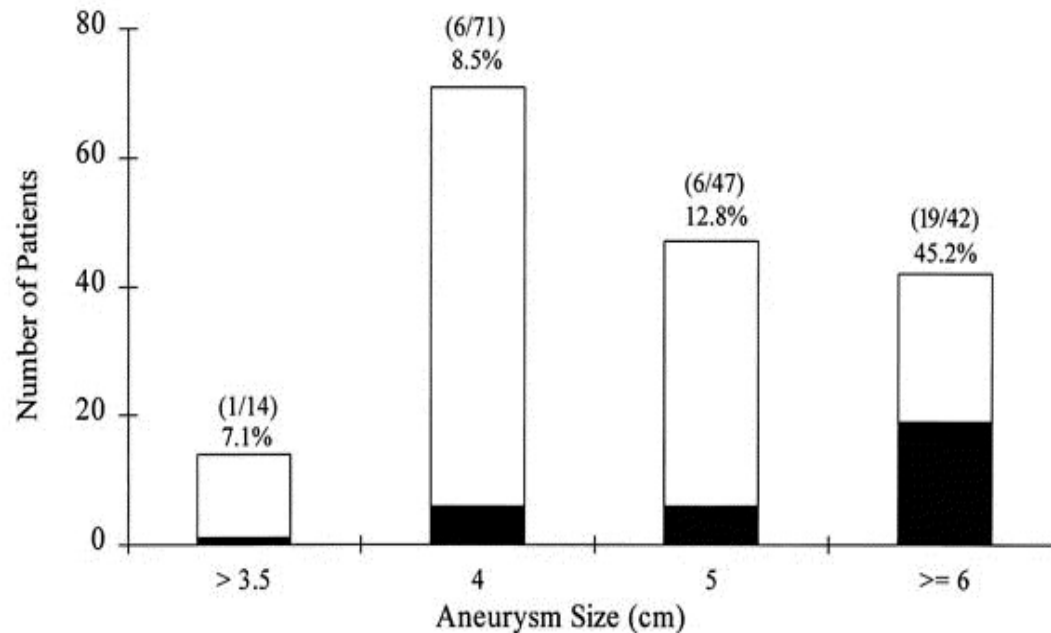
Diameter at time of complication



Ascending / Descending Aneurysms

WHEN SHOULD WE OPERATE?

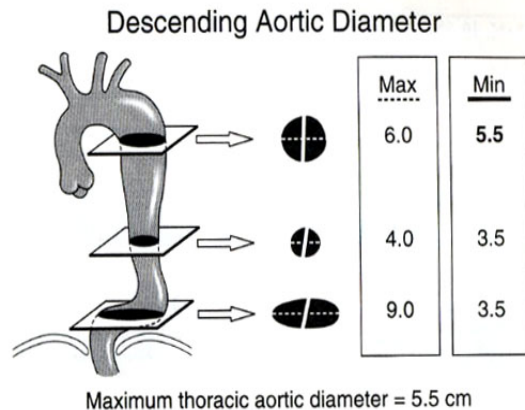
- Incidence of rupture or dissection based on initial size
 - F/U 1-106 months, mean 26 months



- When aneurysms reach 6cm, risk of complication increases

Thoracic Aortic Aneurysm OUTPATIENT FOLLOW-UP

- Center for Diseases of the Thoracic Aorta – Wash. U.
- Incidental Ascending Aortic Aneurysm $\leq 5\text{cm}$
- CT in 4 mo (R/O rapid growth), then 6 mo, then annually
- If initial diameter is in question – 3-D reconstruction / MRI



- Heightened awareness with growth / atypical chest pain

Thoracic Aortic Aneurysms

RISK OF REPLACEMENT

SURGICAL RISK - location, extent of operation, and acuity

- Ascending Only - Elective $1\% \pm 1\%$ 2/174 pts *ATS 2006*
- Valve-Sparing - Marfan $0\% \pm 0\%$ 0/ 73 pts *JTCVS 2009*
- Ascending & Valve – Elective $3\% \pm 1\%$ 4/156 pts *JTCVS 2009*
- TAA - Elective $7\% \pm 2\%$ 13/198 pts *ATS 2006*
- Acute Ascending Dissection $17\% \pm 2\%$ 41/242 pts *J Clin HTN 2013*
- TAA – ruptured/emergent $33\% \pm 6\%$ 20/ 60 pts *ATS 2003*

Thoracic Aortic Aneurysm

SURGICAL INDICATIONS

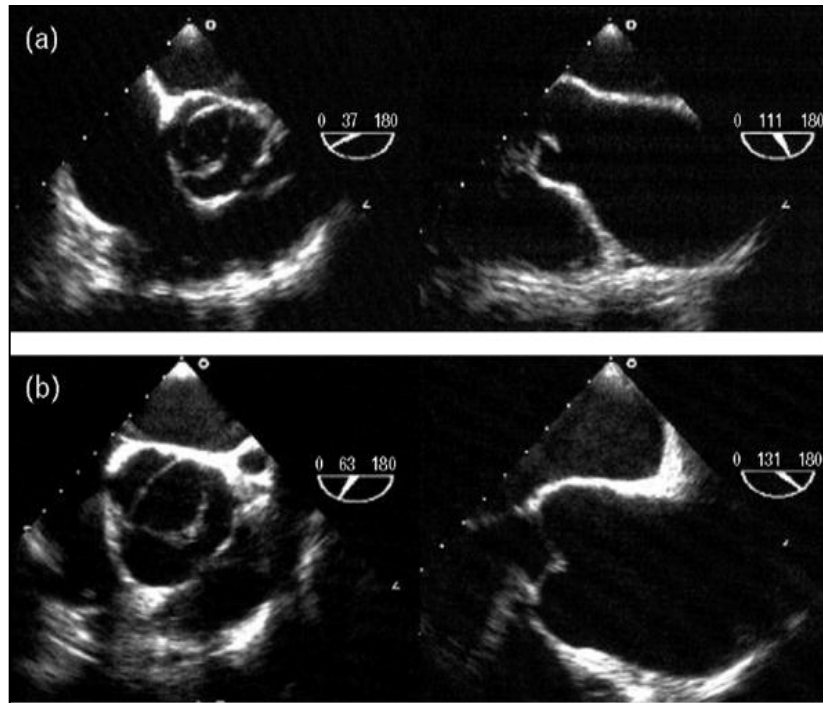
- Indications for Thoracic Aortic Replacement
 - Individualized for each pt: risk of rupture vs. replacement
 - Patient needs to be included in the decision process
 - Sx: pain, hoarseness, swallow/resp difficulties, caval obs, pain
 - Diameter: Asc ≥ 5.5 cm ($> \sim 2x$ nl Ao size), 5.0 cm bicuspid?
 - Growth rate: 5-10 mm / year
 - Localized saccular aneurysm (\uparrow risk? – rare with bicuspid)
 - Marfan: > 4.5 to 5 cm or growth $> 3-5$ mm/yr

Thoracic Aortic Aneurysm

- Anatomy & natural history
- Histopathology & medical treatment options
- When should we operate?
- **Surgical treatment options**

Bicuspid Aortic Valve

ASCENDING AORTIC ANEURYSM

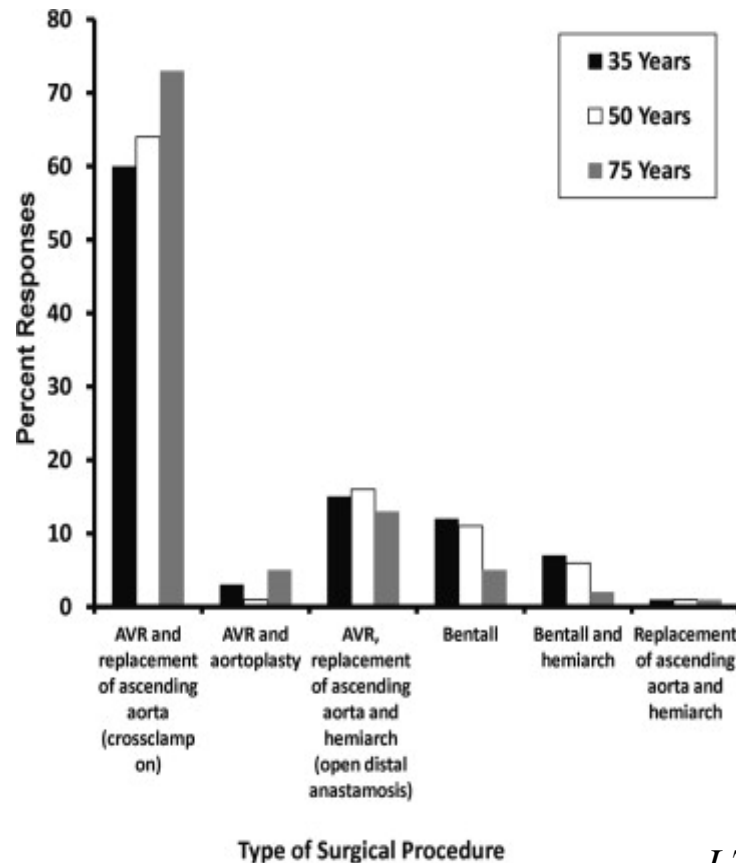


- Ascd only

- Sinuses and
Ascd

Bicuspid Aortic Valve ASCENDING AORTIC ANEURYSM

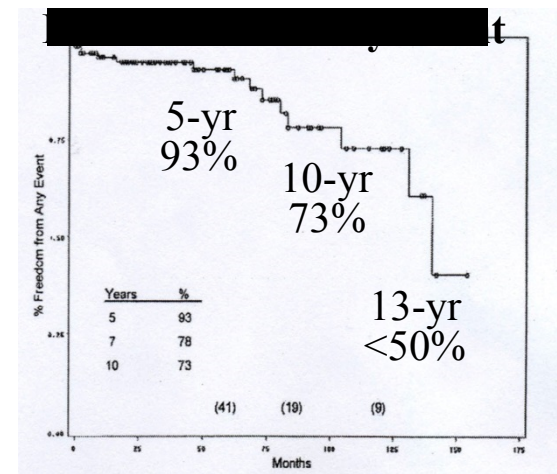
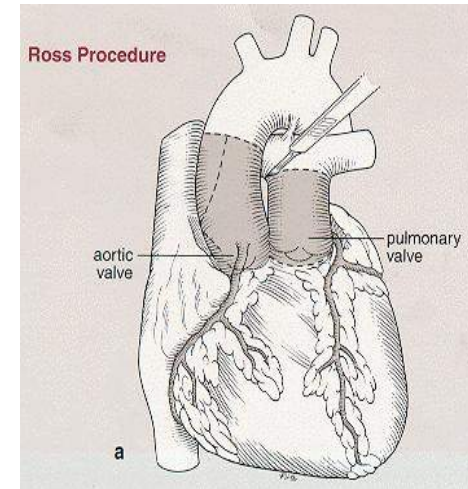
- Effects of age on surgical management: Verma (Toronto) – 100 surgeons
 - 35, 50, 75 yo pt with AS of BAV & 53mm ascd Ao (nl root and arch)



Bicuspid Valve Disease

ROSS PROCEDURE

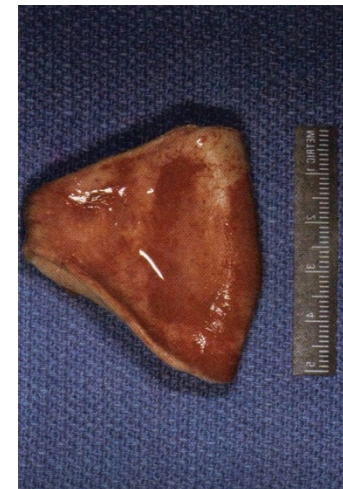
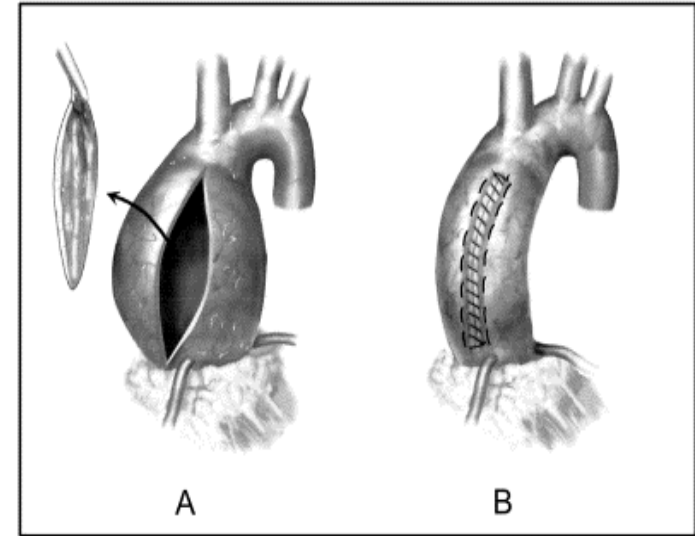
- Replacement of AoV with pulm allograft
 - Complex procedure
 - Initial thoughts: “carefree” solution
 - Recent results have been less optimistic, especially with bicuspid AoV
- Kouchoukos (St. Louis) *ATS* 2004;78:773
 - 25% autograft reop, 14% homograft reop
- Wash U. *JTCVS* 2001;122:1249
 - “Undo” Ross for ↑ Asc d Ao
 - abrupt transition at distal suture line
 - elastin fragmentation and CMN



Bicuspid Valve Disease

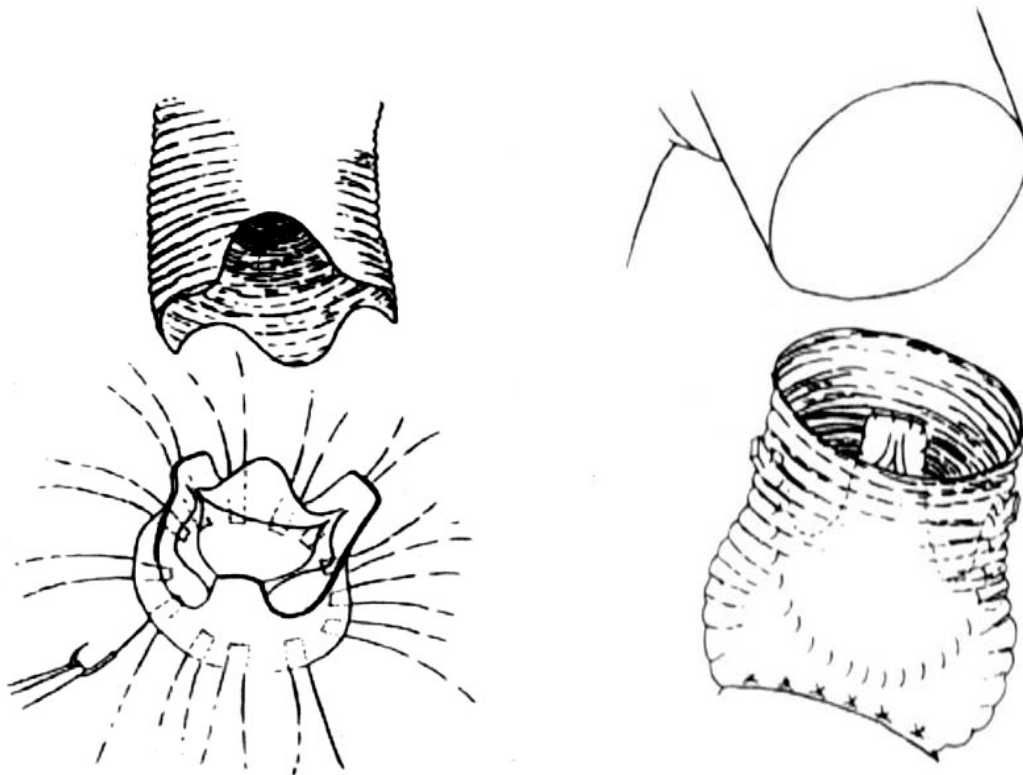
REDUCTION AORTOPLASTY

- Not appropriate for standard aneurysms
- May play a role with “generous” Ao
 - Mayo Clinic – 14 pts ATS 2002;73:1332
- Potential Patient: Undergoing AVR for Bicuspid AS/AI with 3.5 cm Ao?
 - return Ao to nl size → ↓ wall stress?
- Tenacious life-long BP control!



Valve-Sparing Root Replacement Reimplantation or 'David' Technique

- Graft replacement of sinuses and ascd Ao
- valve leaflets - reimplanted within the graft
- Attachment of coronary ostia to graft

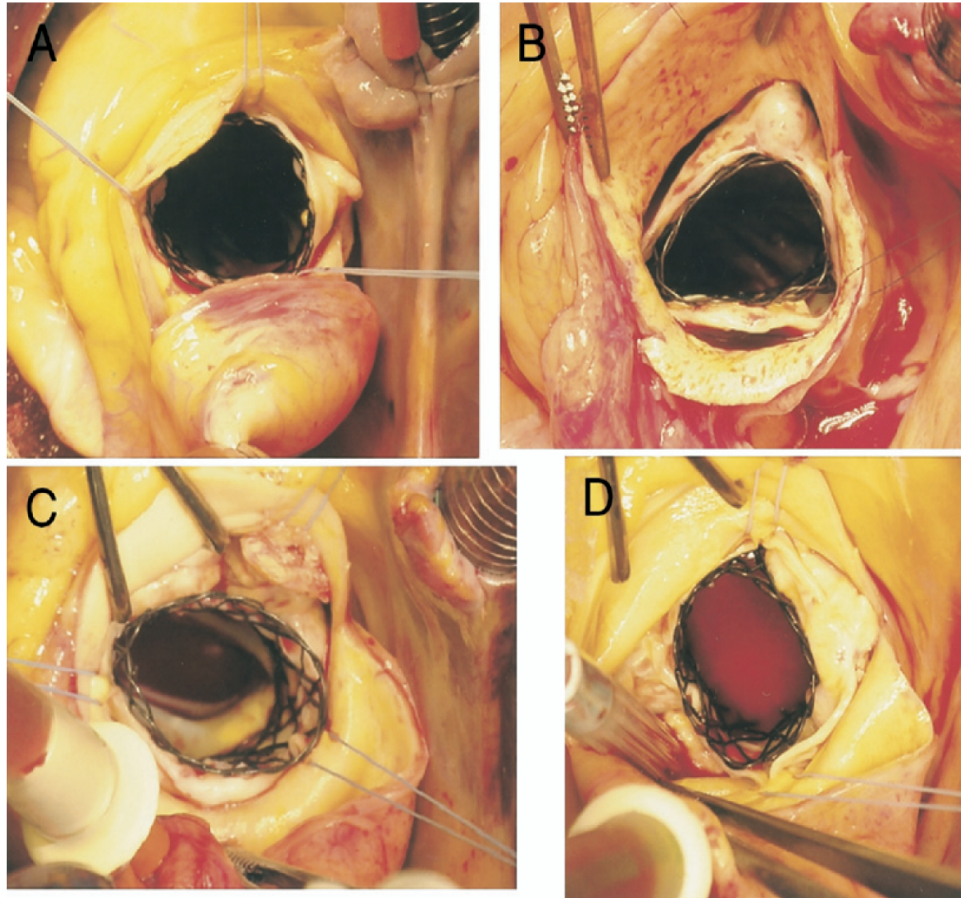


- Intraop view looking at valve before reimplantation into dacron graft



Transcatheter Heart Valves

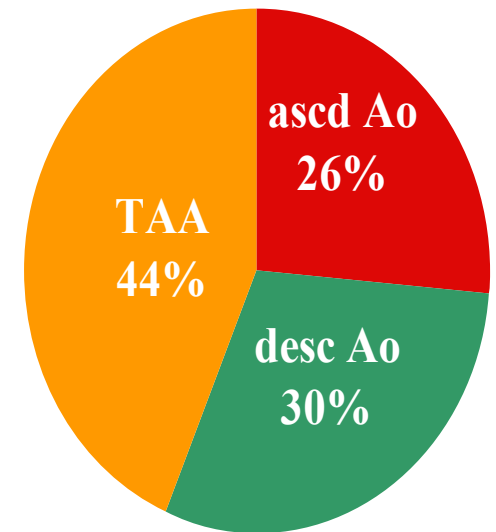
Problems with Bicuspid Valves



Elective thoracic Ao replacement

PATIENT POPULATION

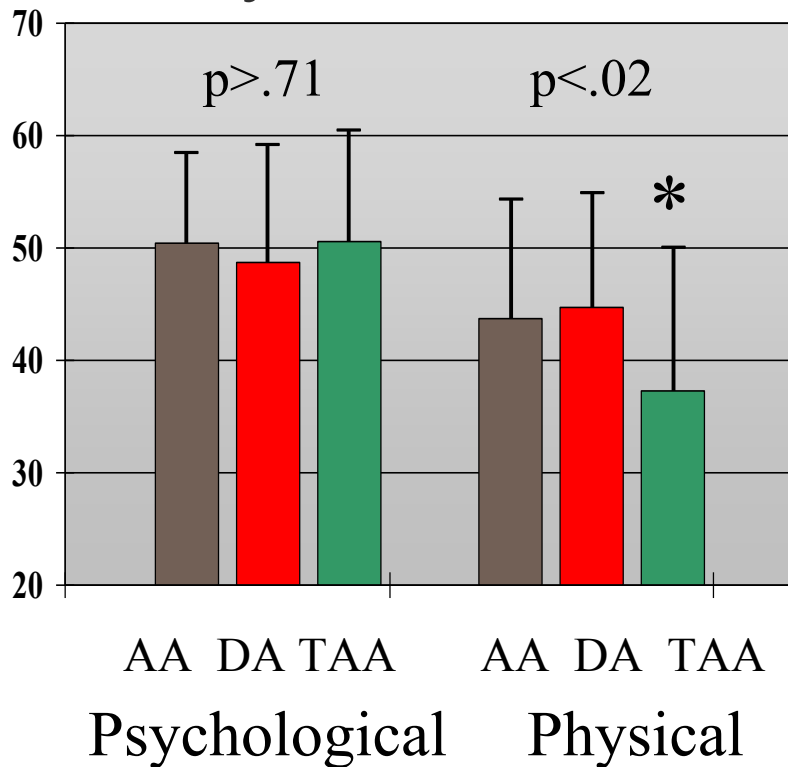
- 5 year period (Jan 1998 to April 2003)
- 110 patients – elective Ao replace (Ø AVR)
 - Ascending Ao: 29 (26%)
 - Descending Ao: 33 (30%)
 - Thoracoabdominal Ao: 48 (44%)
 - I: 8 (17%), II: 26 (54%), III: 14 (29%)



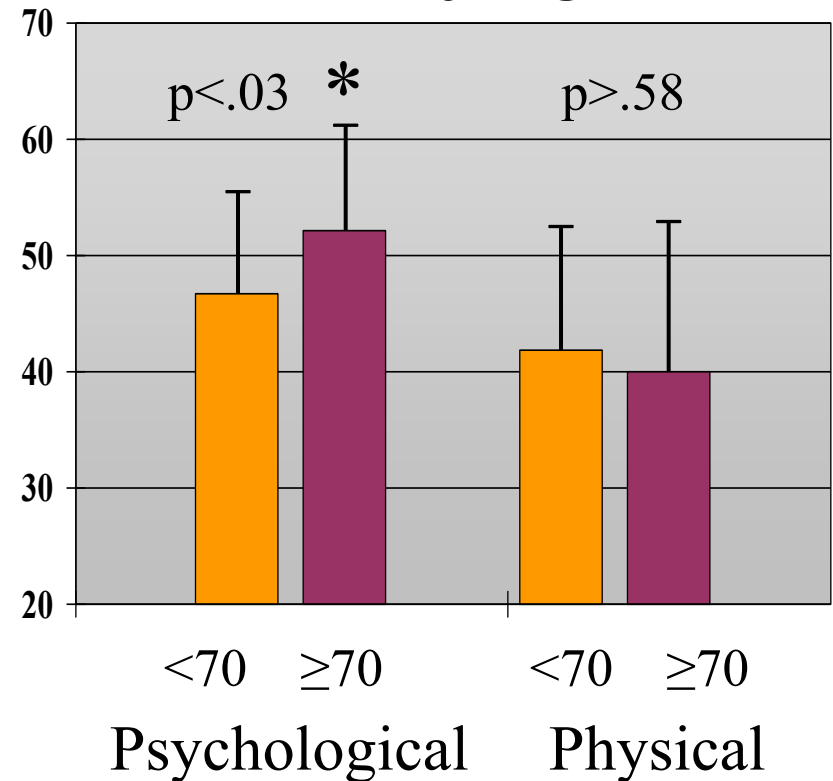
Elective thoracic Ao replacement

Psychological & physical composite QOL

By Procedure



By Age

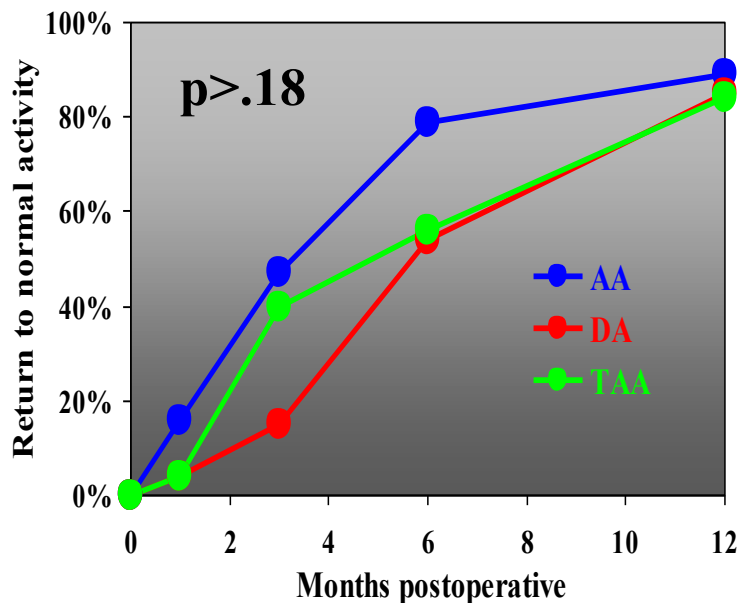


- psych and physical scores: weighted avg of 8 domains at 35 ± 20 mo
- score: 0 to 100 (\uparrow scores \rightarrow \uparrow function), age-matched US norm: mean = 50

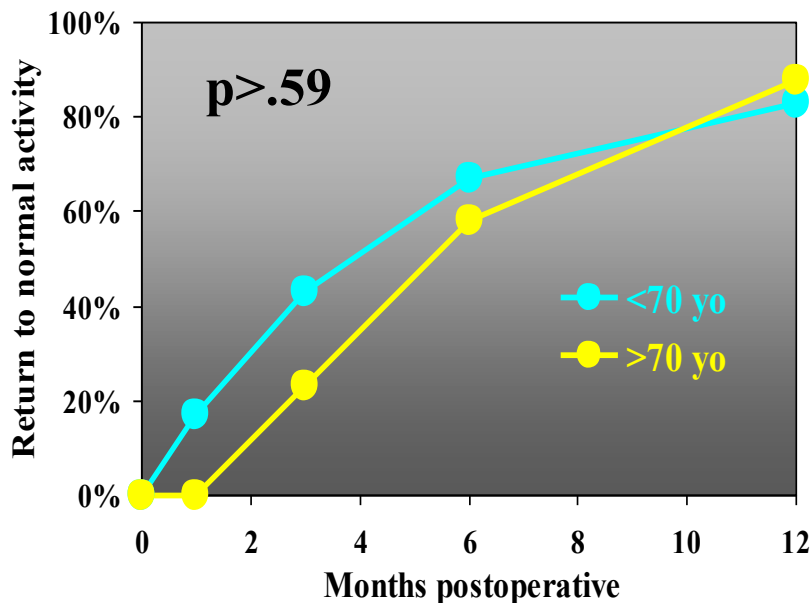
Elective thoracic Ao replacement

Return to normal activity

By Procedure



By Age



- At 6 and 12 months, 39% and 14% reported ↓ activity compared to preop levels
- No difference with procedure ($p > .18$) or age ($p > .59$)

Ascending Aortic Surgery: How, When, and for Whom?

- Anatomy & natural history
- Histopathology & medical tx options
- When should we operate?
- Surgical treatment options



Thank you

Heart & Vascular Center



N A T I O N A L L E A D E R S I N M E D I C I N E