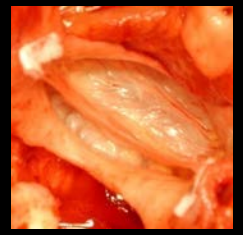
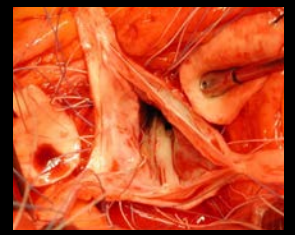


Surgical Options for Aortic Valve Insufficiency in the Young

Andrew B. Goldstone, MD, PhD
Columbia University Vagelos College of Physicians and Surgeons
Morgan Stanley Children's Hospital
New York-Presbyterian

Columbia University Medical Center

NewYork-Presbyterian

Disclosures

- None

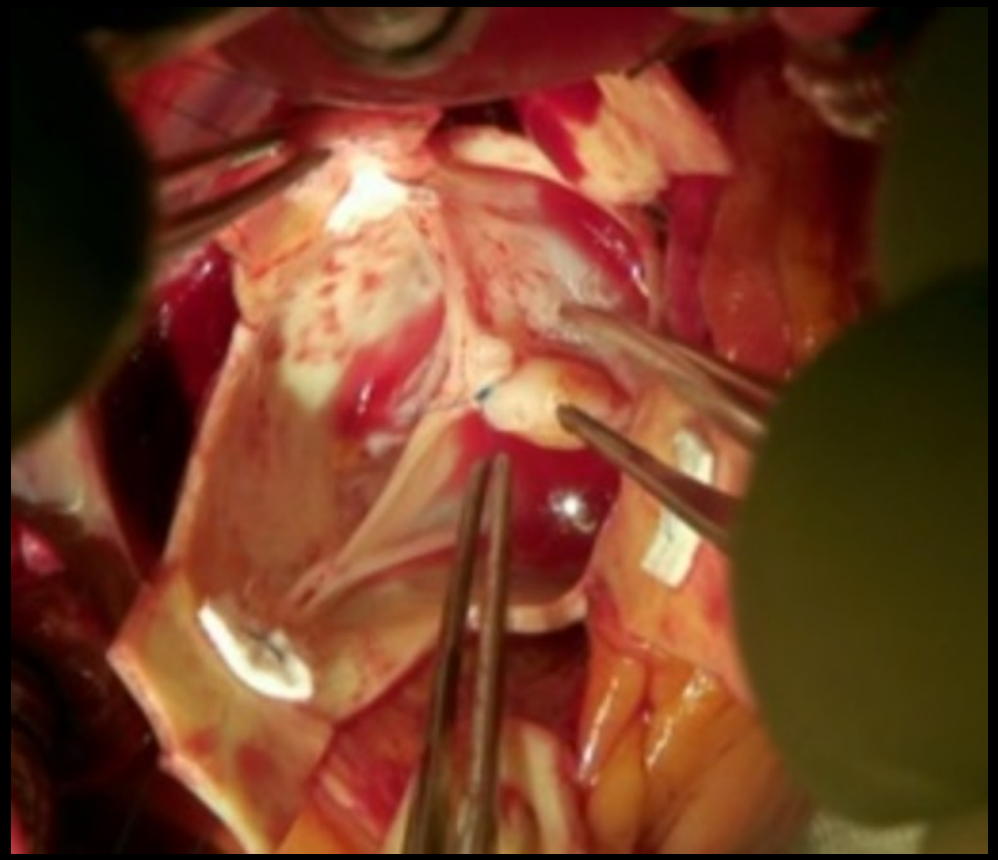
Spectrum of Aortic Valve Disease

Predominantly AS

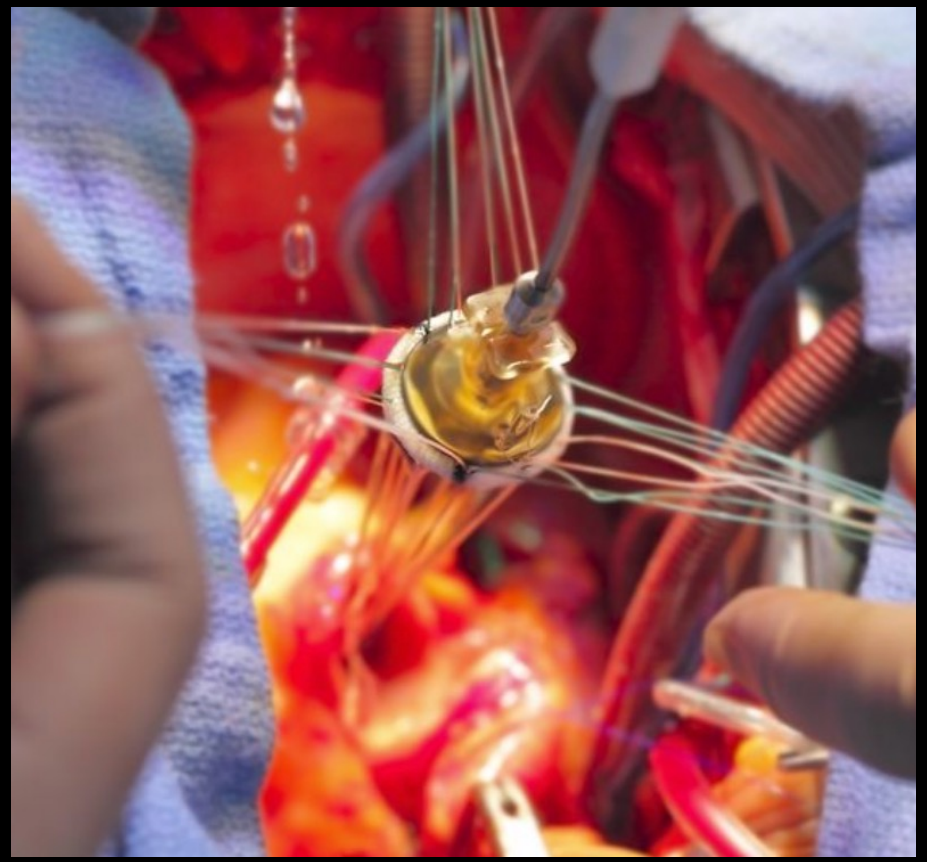
Predominantly AS

AI becomes a significant phenotype

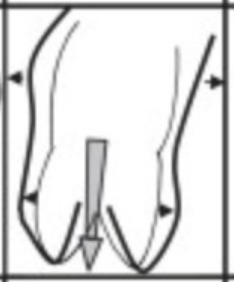
Repair



Replacement



Mechanism of Disease is Key

AI Class	Type I Normal cusp motion with FAA dilatation or cusp perforation				Type II Cusp Prolapse	Type III Cusp Restriction
	Ia	Ib	Ic	Id		
Mechanism						
Repair Techniques (Primary)	STJ remodeling *Ascending aortic graft*	Aortic Valve sparing: *Reimplantation or Remodeling with SCA*	SCA	Patch Repair *Autologous or bovine pericardium*	Prolapse Repair *Plication* *Triangular resection* *Free margin Resuspension* *Patch*	Leaflet Repair *Shaving* *Decalcificatio* *Patch*
(Secondary)	SCA		STJ Annuloplasty	SCA	SCA	SCA

Boodhwani et al. JTCVS 2009

Freedom From Reoperation in Aortic Valve Sparing Surgery

						Freedom from Adverse Events		
1st Author	Yr	N	BAV (%)	Mean or Median f/u (years)	Time	Reoperation	AR	TAV vs. BAV
Reimplantation								
David et al	2013	296	11%	6.9	5-yr	99.7%	98.3%	Ø Difference
					10-yr	97.8%	92.9%	
					15-yr	97.8%	89.4%	
Liebrich et al	2013	236	15%	4.5	5-yr	94%	94%	Ø Difference
					10-yr	87%	91%	
Kvitting et al	2013	233	27%	4.7	5-yr	98%	97.4%	Ø Difference
					10-yr	92.2%	95/3%	
Reimplantation ± Remodeling								
Lansac et al	2010	144	23%	2.2	3-yr	93.3%	87%	Ø Difference

David, T. E., Armstrong, S., Manlhiot, C., McCrindle, B. W., & Feindel, C. M. (2013). Long-term results of aortic root repair using the reimplantation technique.

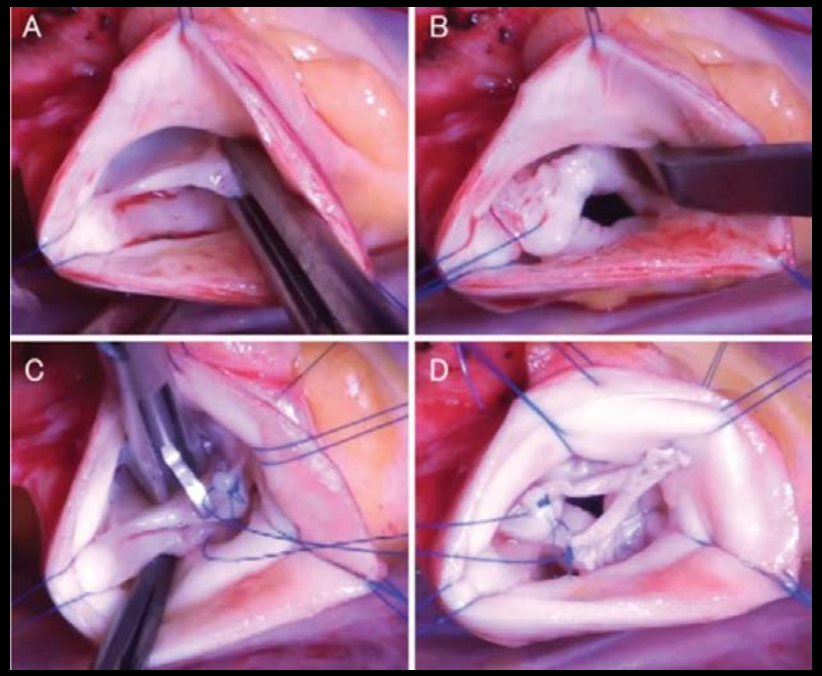
Liebrich, M., Kruszynski, M. K., Roser, D., Meisner, C., Doll, K. N., Hemmer, W. B., & Weimar, T. (2013). The David procedure in different valve pathologies: a single-center experience in 236 patients. The Annals of thoracic surgery, 95(1), 71-76.

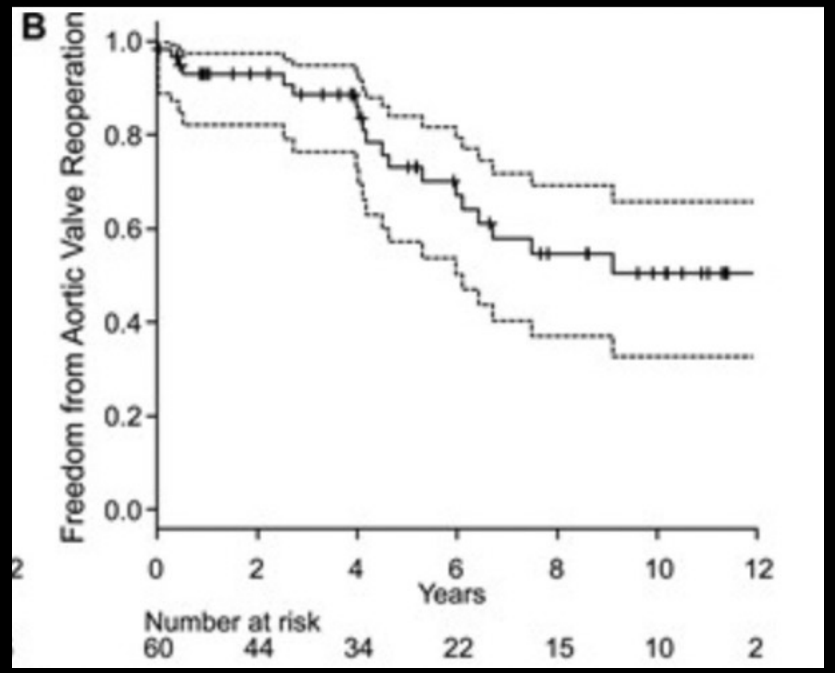
Kvitting, John-Peder Escobar, Fabian A. Kari, Michael P. Fischbein, David H. Liang, Anne-Sophie Beraud, Elizabeth H. Stephens, R. Scott Mitchell, and D. Craig Miller. "David valve-sparing aortic root replacement: equivalent mid-term outcome for different valve types with or without connective tissue disorder." The Journal of thoracic and cardiovascular surgery 145, no. 1 (2013): 117-127.

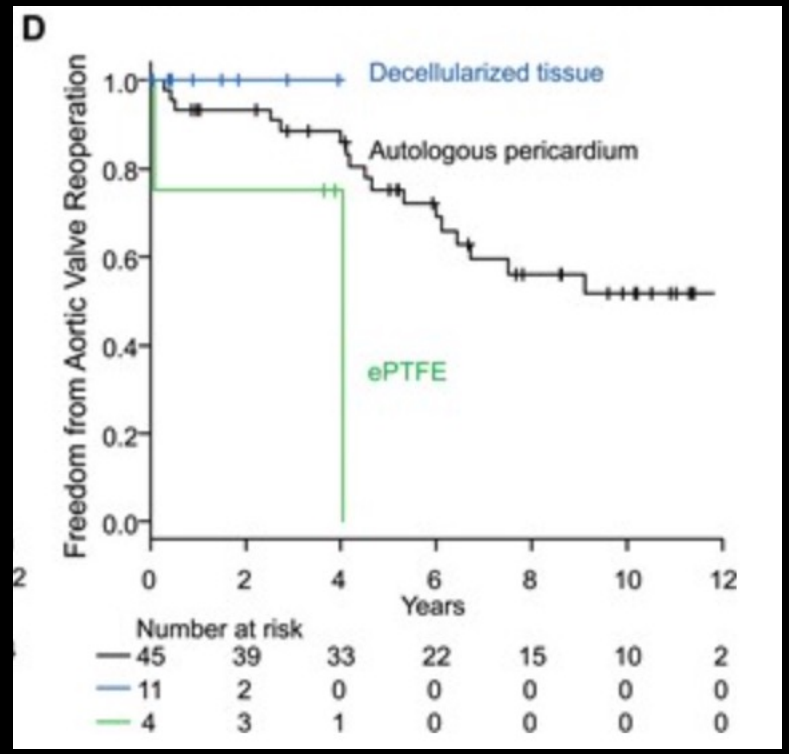
Lansac E, Di Centa I, Sleilaty G, Bouchot O, Arnaud Crozat E, Blin D, Acar C, Debauchez M. An aortic ring to standardise aortic valve repair: preliminary results of a prospective multicentric cohort of 144 patients. Eur J Cardiothorac Surg. 2010;38(2):147-54.

David TE. Aortic Valve Sparing in Different Aortic Valve and Aortic Root Conditions. J Am Coll Cardiol. 2016;68(6):654-64.

Pediatric Aortic Valve Repair Techniques







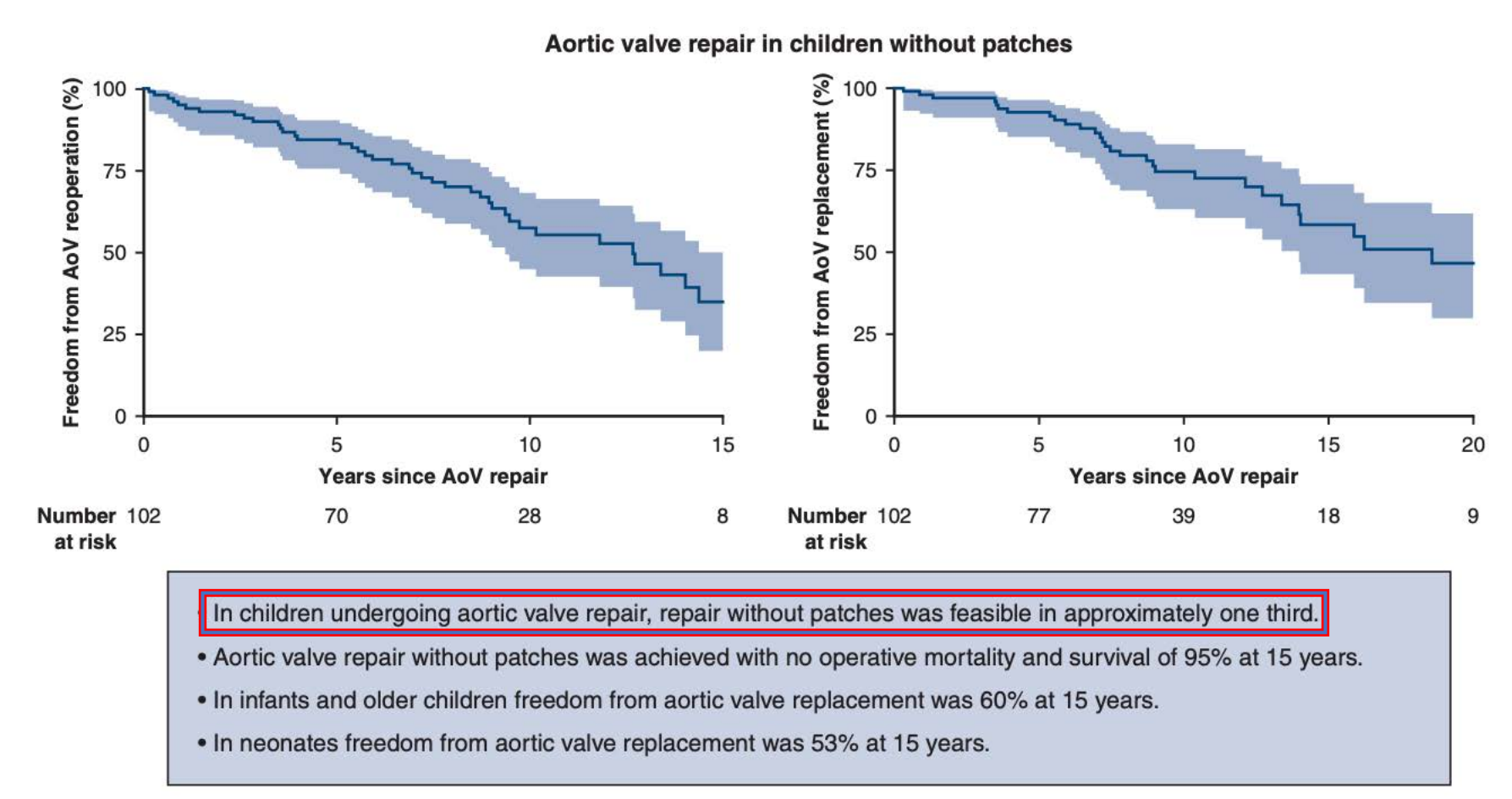
N=60

Median age 13 (1 to 18)

37% AI, 45% mixed

Matsushima et al. EJCTS 2021

Repair Without Patch Promising



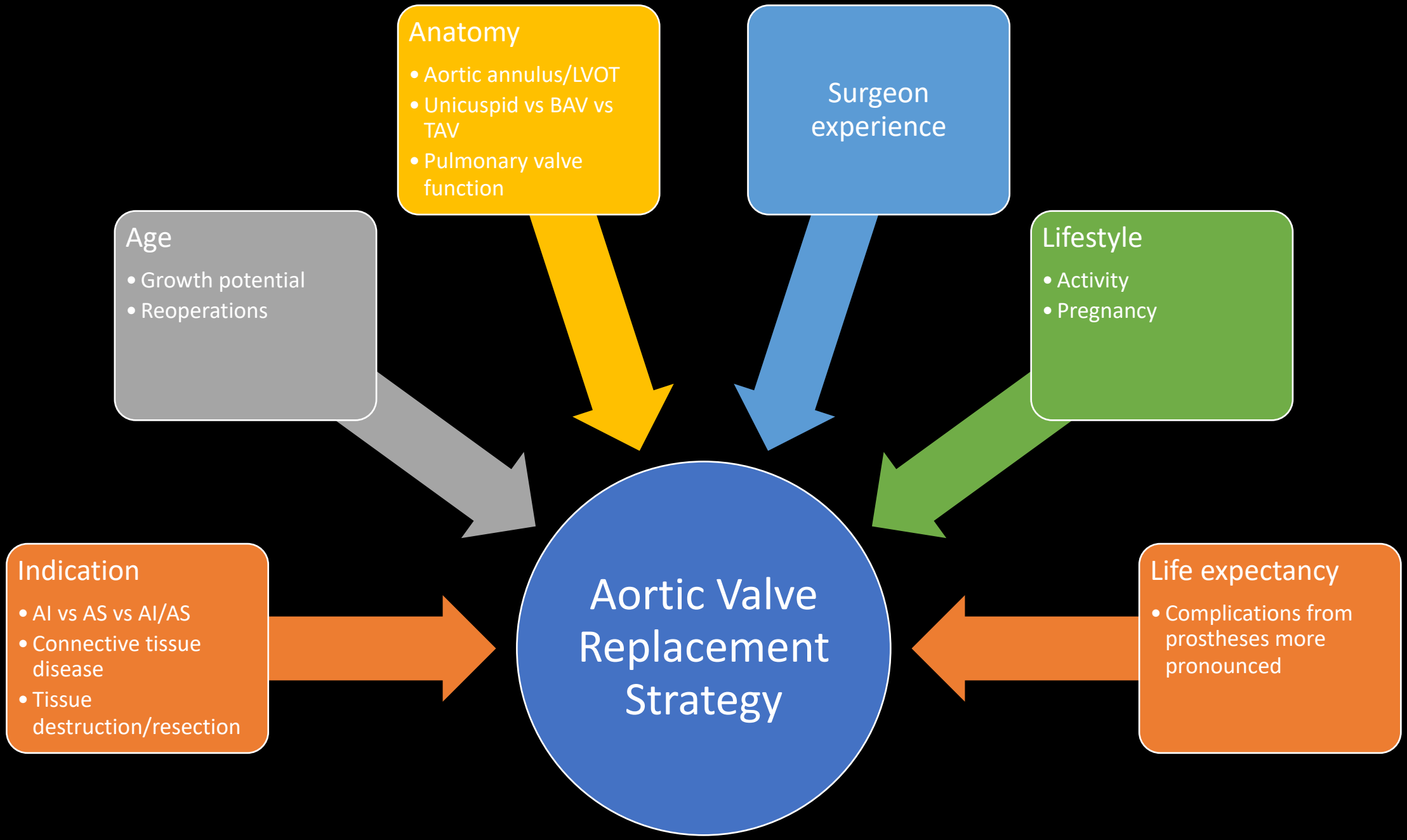
Wallace et al. JTCVS 2021

Relative Contraindications to Valve Repair

Significant calcification of annulus and cusps
Multiple fenestrations of cusp tissue
Severe free margin thickening
Multiple leaflet prolapse
A deficiency of sinus wall tissue immediately adjacent to the line of leaflet insertion

WHY? – Because durability limited!

If DURABLE Repair Cannot be Achieved…


Anatomy
• Aortic annulus/LVOT
• Unicuspid vs BAV vs TAV
• Pulmonary valve function
Surgeon experience
Age
• Growth potential
• Reoperations
Lifestyle
• Activity
• Pregnancy
Indication
• AI vs AS vs AI/AS
• Connective tissue disease
• Tissue destruction/resection
Aortic Valve Replacement Strategy
Life expectancy
• Complications from prostheses more pronounced

Options for AVR

TISSUE VALVES:
Sizes available: 19mm-29mm

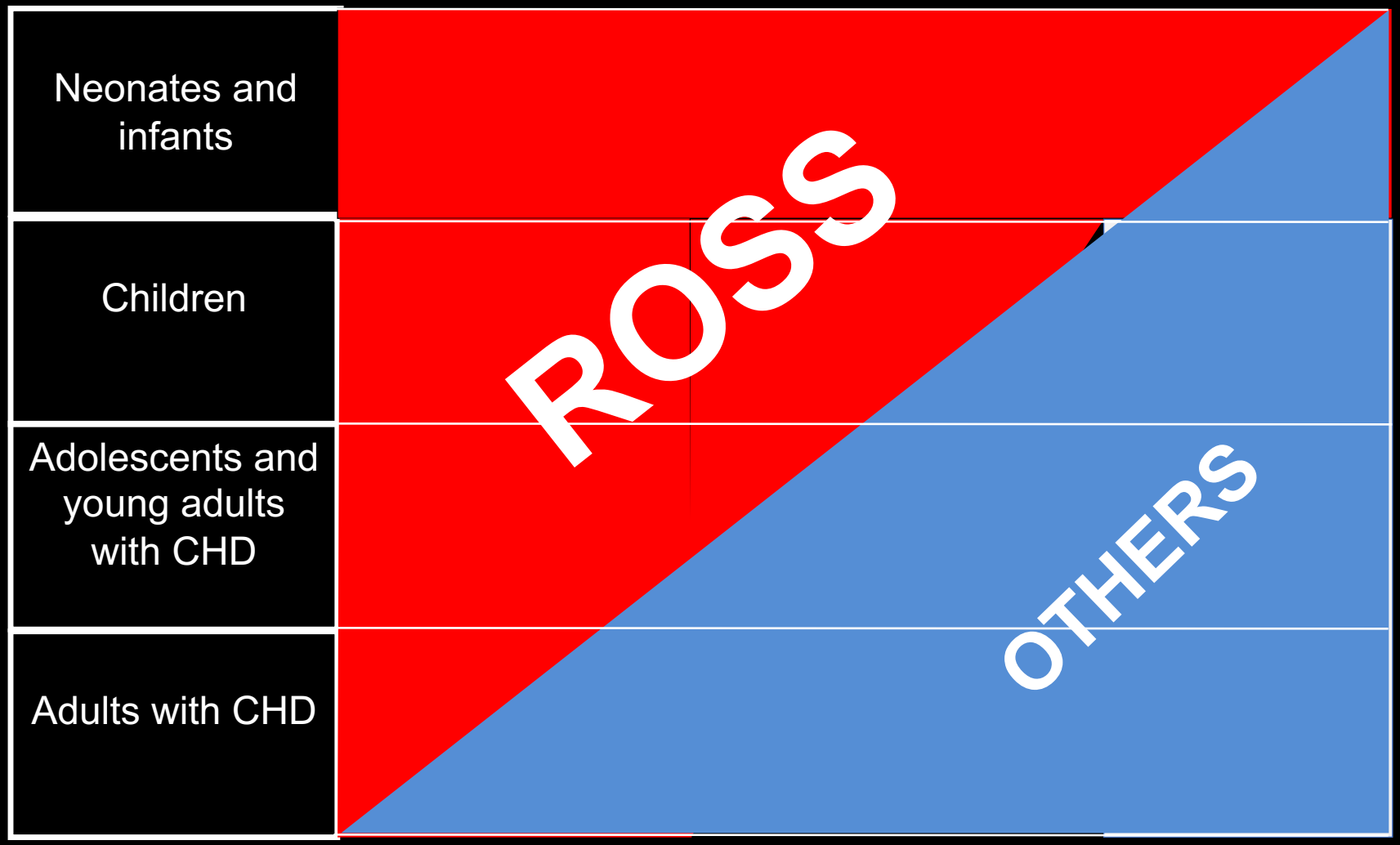
HOMOGRAFTS:
Sizes available: 7mm-32mm

OZAKI:
Sizes available: no limits

MECHANICAL VALVES:
Sizes available: 15mm-27mm

ROSS PROCEDURE:
Sizes available: no limits

AVR Strategies in CHD: The Preponderance of the Ross Procedure

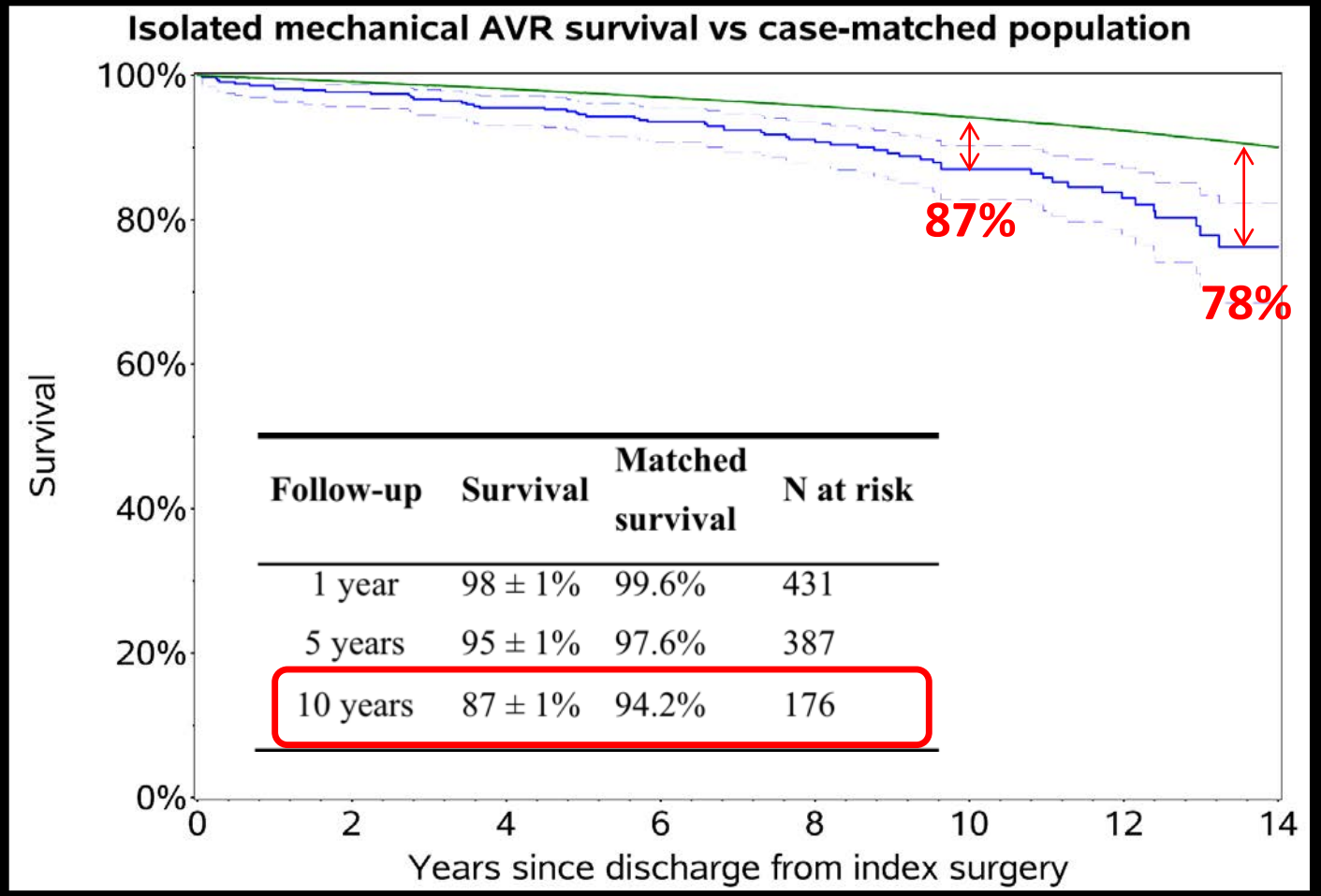


Mechanical Prostheses in the Young

- Smallest one 15mm (Can an adult-sized prosthesis be implanted?)
  - Annular enlargement techniques
- Significant mortality:
  - Operative mortality: 2-13%
  - Constant attrition: 75-88% survival at 15 years
- Anticoagulation:
  - Challenging / compliance
  - 0.3–0.7 TE events per 100 patient-years < adult but constant attrition
  - Pregnancy – only 28% good maternal and fetal outcome in UK
- Long-lasting … in theory:
  - Freedom from AVR: 55–90% at 15 years!
  - Patient-prosthesis mismatch
  - Pannus formation
  - Endocarditis

Mechanical AVR Lowers Survival

450 young adults



Follow-up	Survival	Matched survival	N at risk
1 year	98 ± 1%	99.6%	431
5 years	95 ± 1%	97.6%	387
10 years	87 ± 1%	94.2%	176

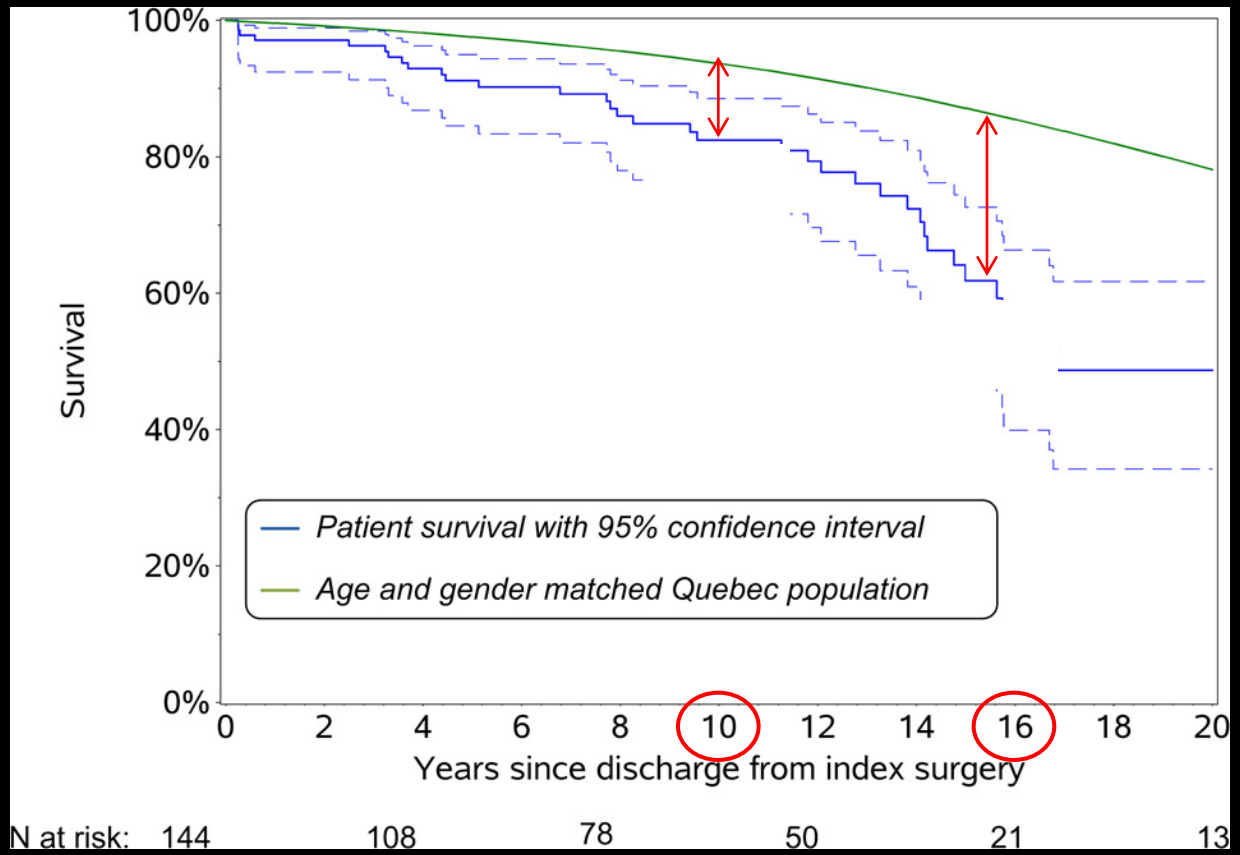
Bouhout et al. JTCVS 2014

Tissue Prostheses in the Young

- Smallest one 19mm
- Early failures/calcifications
  - SVD >> adults
  - Inversely related to patient age and prosthesis size
    - Karamlou circulation 2005, Alsoufi EJCTS 2009,…
    - Freedom from AV reoperation: 35% at 10 years; 15% at 15 years
- Valve-in-valve now available
  - Durability unknown, gradients higher
- No meds (baby ASA)
- Indications?
  - Teenage females
  - Poor compliance with anticoagulation

Tissue AVR Lowers Survival

144 adults



~ 80% at 10 yrs

~ 60% at 15 yrs

Forcillo et al. ATS 2014

In young adults, the problem of early bioprosthetic valve degeneration is well known

Mortality and Reoperation Risk After Bioprosthetic Aortic Valve Replacement in Young Adults With Congenital Heart Disease

Stephanie M. Fuller, MD, MS,[*] Michele J. Borisuk, MSN, CPNP,[†] Lynn A. Sleeper, ScD,[†,‡] Emile Bacha, MD,[§] Luke Burchill, MD,[¶] Kristine Guleserian, MD,[**] Michel Ilbawi, MD,[††] Anees Razzouk, MD,[‡‡] Takeshi Shinkawa, MD,[§§] Minmin Lu, MS,[†] and Christopher W. Baird, MD[¶¶]

8 Centers

2000-2014

95 patients <21 yrs

In young adults, the problem of early bioprosthetic valve degeneration is well known

Mortality and Reoperation Risk After Bioprosth in Young Ad ease

Stephanie M. Fu
Emile Bacha, M
Anees Razzouk,
n A. Sleeper, ScD,[†,‡]
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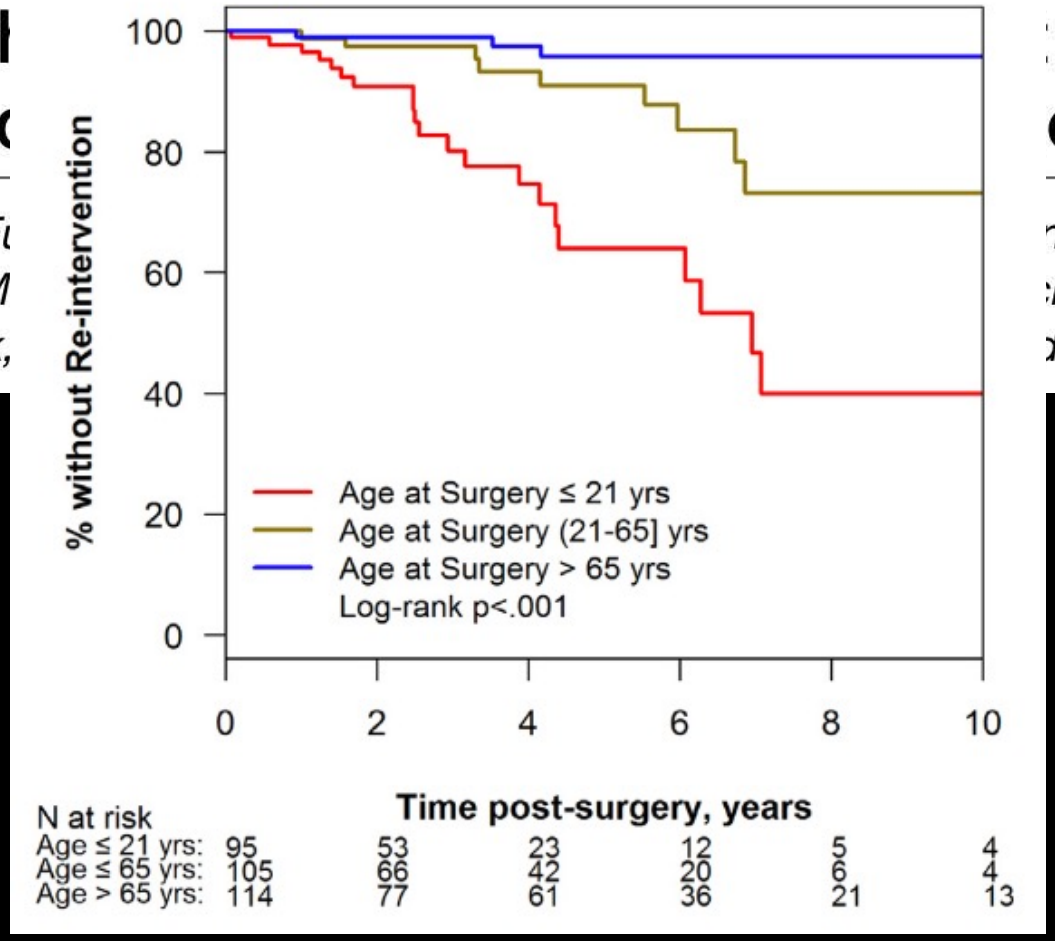
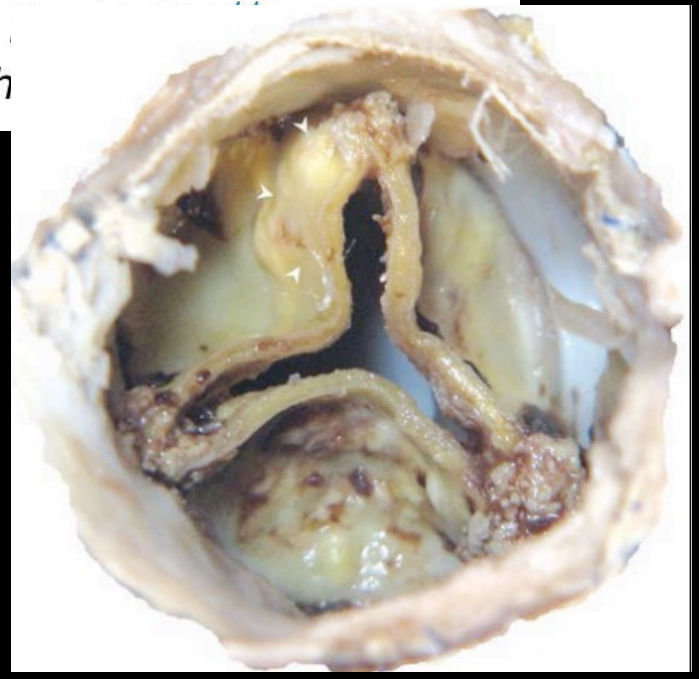
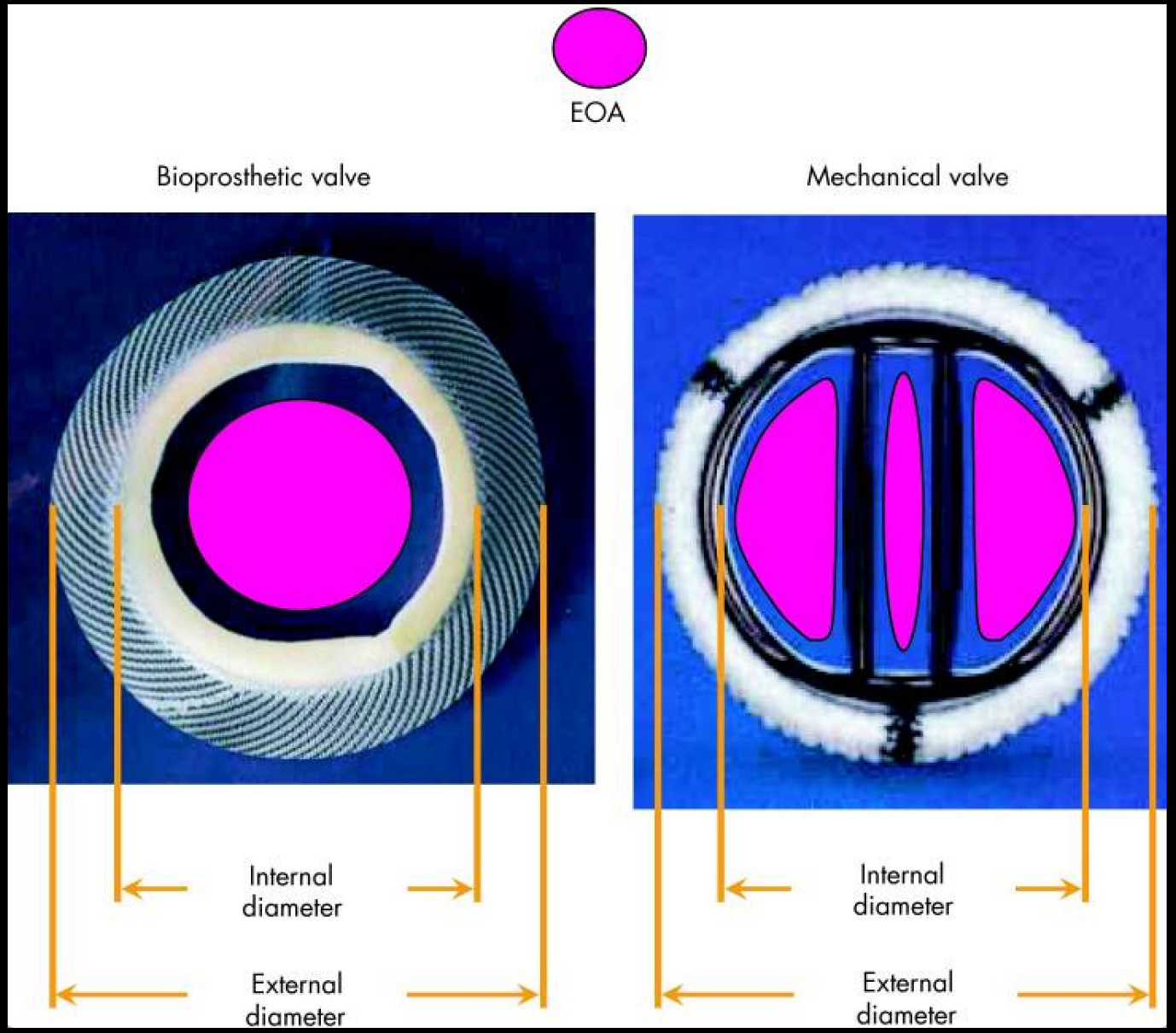






We need a valve that:

1) **Is durable**
2) **Grows**
3) **No anticoagulation needed**
4) **Has outstanding hemodynamics**

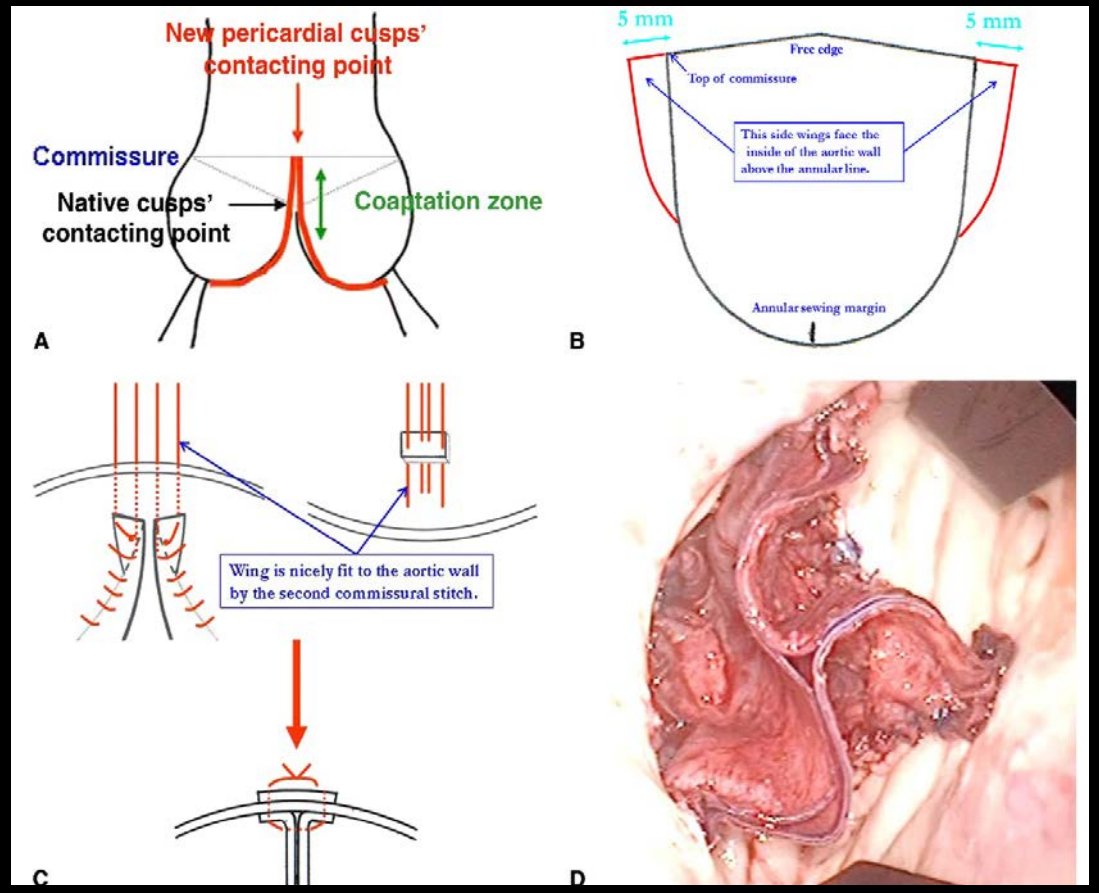
Congenital aortic and truncal valve reconstruction using the Ozaki technique: Short-term clinical results

Christopher W. Baird, MD,[a,b] Brenda Cooney, PA-C,[a] Mariana Chávez, MD,[a] Lynn A. Sleeper, ScD,[b,c] Gerald R. Marx, MD,[b,c] and Pedro J. del Nido, MD[a,b]

57 Ozaki patients; median follow-up 8 mos

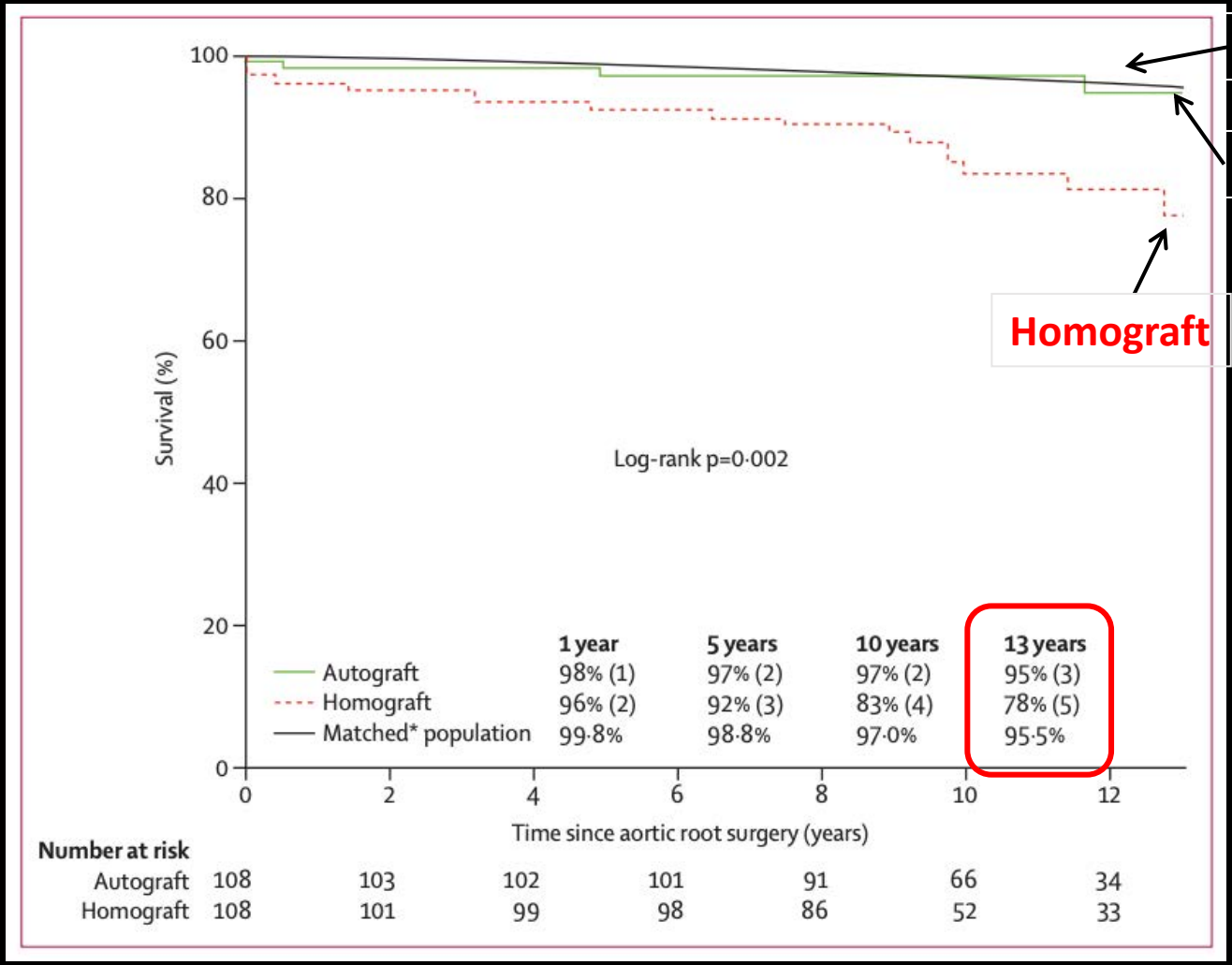
Freedom from at least mod AR 88% at 2 yrs
Freedom from at least mod AS 88% at 2 yrs

Reduced leaflet mobility -> ~50% of patients on coumadin + ASA



The Ross Advantage: Survival

The Ross is the ONLY AVR procedure that demonstrates long term survival equal to the general population in adults



GENERAL POPULATION

ROSS

Homograft

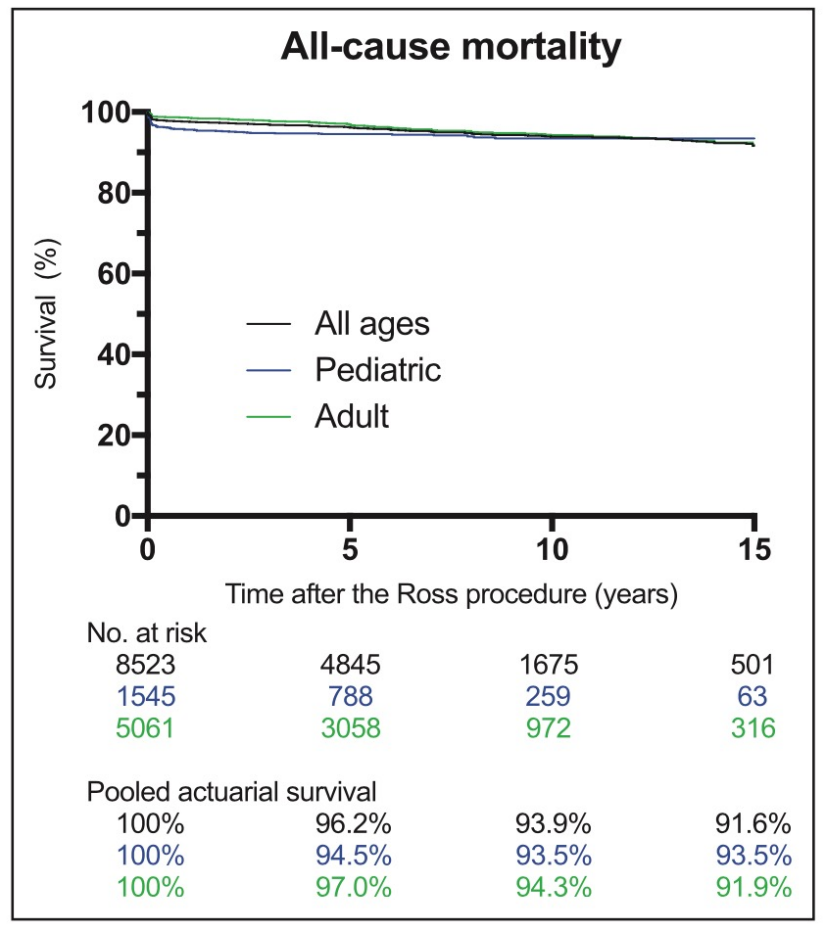
Avg age 39 yrs

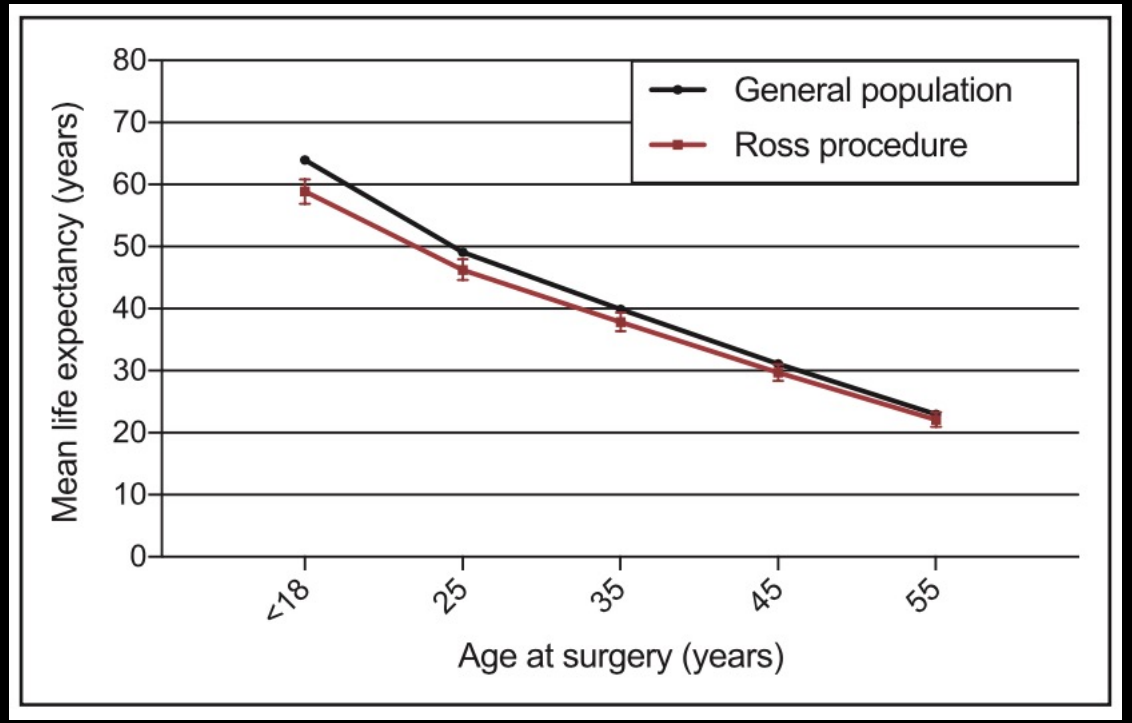
El-Hamamsy et al. Lancet 2010

ORIGINAL ARTICLE

The Ross Procedure: A Systematic Review, Meta-Analysis, and Microsimulation

99 publications; 6,892 adults, 2,743 children 2000-2017



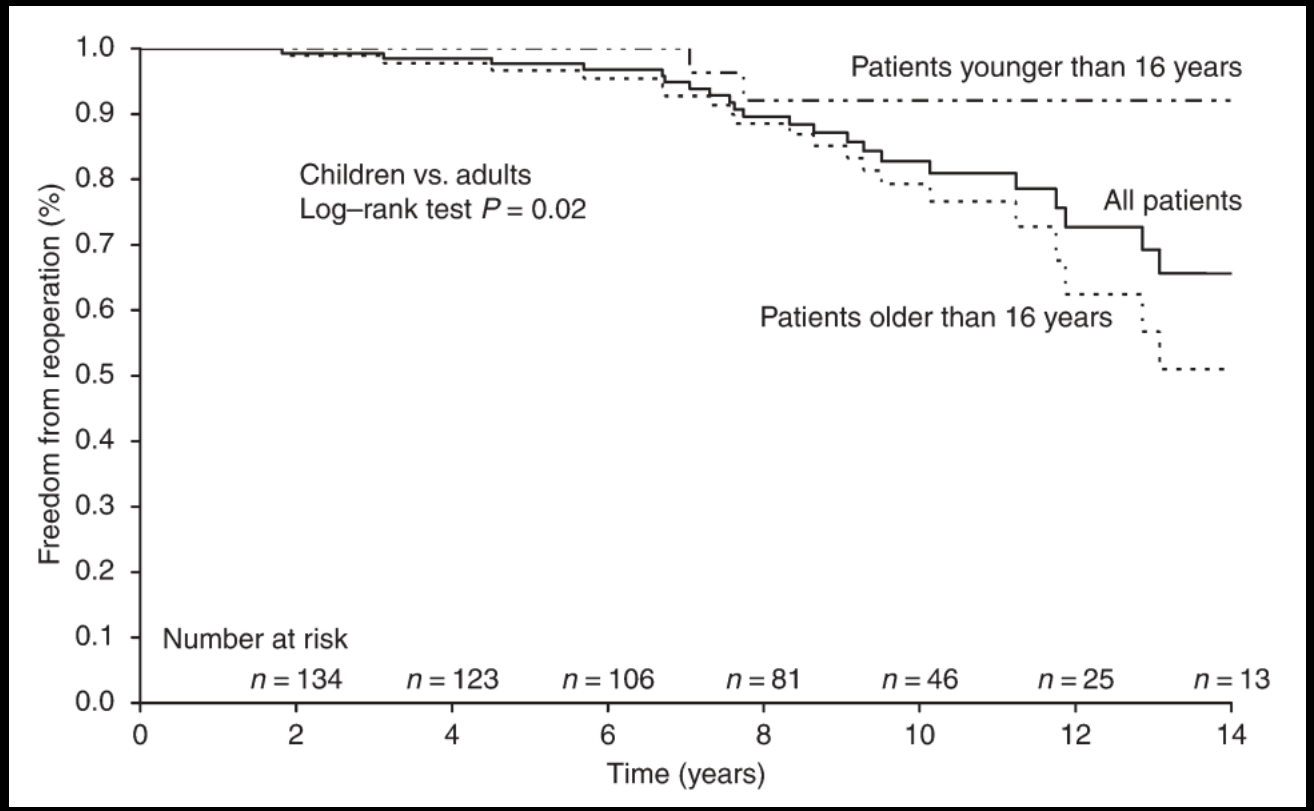


Etnel et al. Circ Cardiovasc Qual Outcomes 2018

The Ross operation: a Trojan horse?†

Loes M.A. Klieverik[1]*, Johanna J.M. Takkenberg[1], Jos A. Bekkers[1], Jolien W. Roos-Hesselink[2], Maarten Witsenburg[3], and Ad J.J.C. Bogers[1]

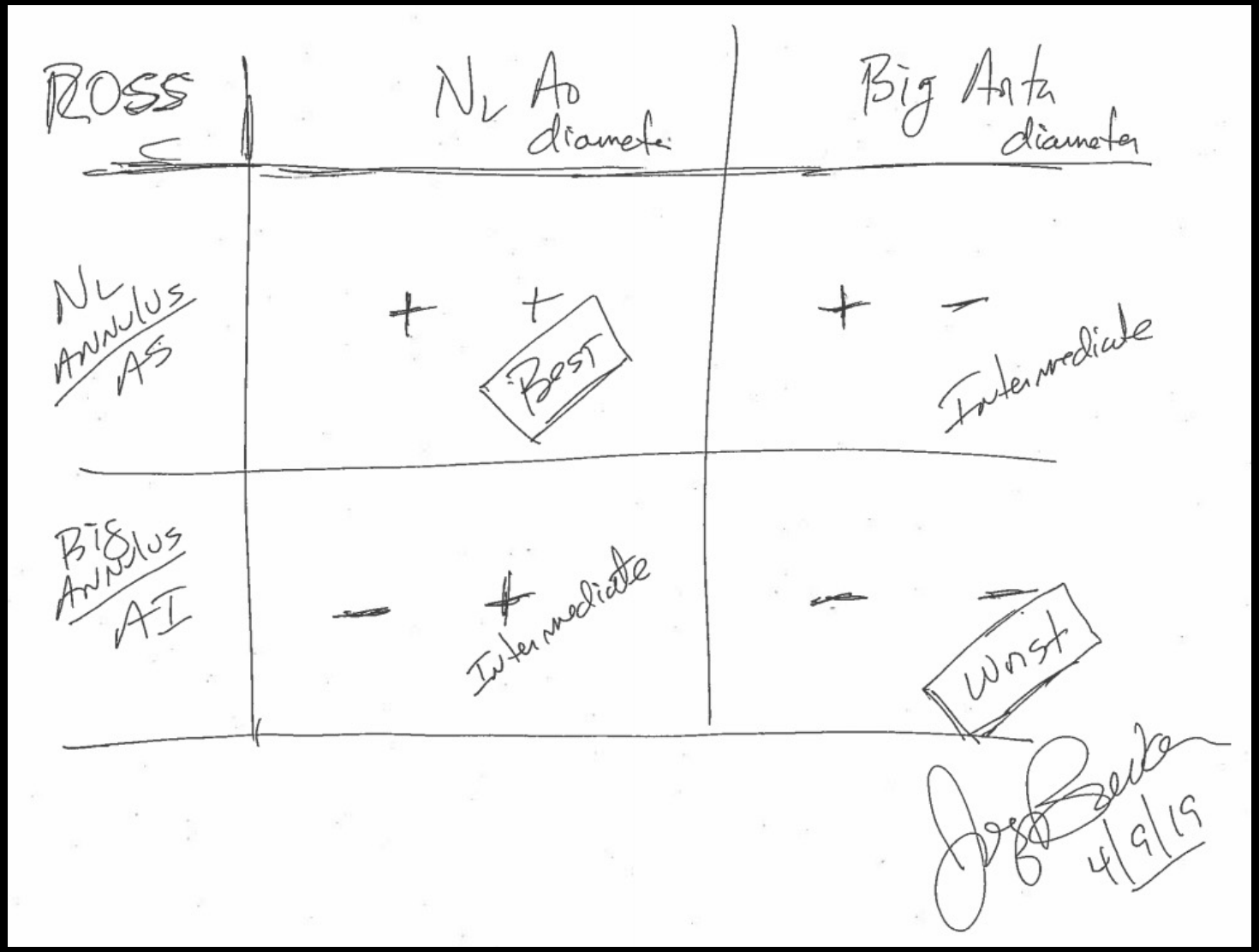
[1]Department of Cardio-Thoracic Surgery, Erasmus University Medical Center, Bd 571, PO Box 2040, 3000 CA, Rotterdam, The Netherlands; [2]Department of Cardiology, Erasmus University Medical Center, Rotterdam, The Netherlands; and [3]Department of Cardiology, Erasmus University Medical Center, Rotterdam, The Netherlands



"Although survival of the Rotterdam autograft cohort is excellent, over time a worrisome increase in reoperation rate is observed."

69% freedom from reop at 13 yrs

The indication for which you do a Ross matters



Factors impacting long-term pulmonary autograft durability after the Ross procedure

Ravil Sharifulin, MD, Alexander Bogachev-Prokophiev, MD, Sergey Zheleznev, MD, Igor Demin, MD, Alexey Pivkin, MD, Alexander Afanasyev, MD, and Alexander Karaskov, MD

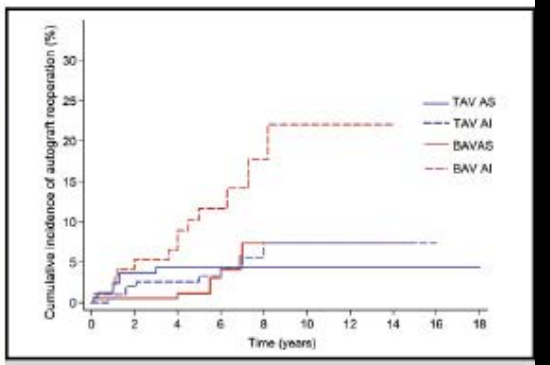
ABSTRACT

Objective: Although the Ross procedure provides excellent long-term survival and a high quality of life, its use has been limited to relatively few centers. In this study, we evaluated long-term Ross procedure results in adults to assess the predictors of pulmonary autograft durability.

Methods: Between 1998 and 2015, 793 consecutive adult patients underwent the Ross procedure. The total root replacement technique was used in all patients.

Results: The early mortality rate was 2.9%. The mean follow-up duration was 6.5 ± 3.2 years, and the 10-year survival rate was 90.4%. Longitudinal mixed-effects ordinal regression identified a combination of bicuspid aortic valve and aortic insufficiency (odds ratio, 2.19; $P < .001$) as predictors for progression of autograft valve insufficiency at follow-up. The cumulative incidence of autograft reoperations at 10 years was 8.6%. Competing risk regression identified bicuspid aortic valve insufficiency as the independent predictor of autograft reoperation (subdistribution hazard ratio, 2.16; $P = .030$). Moreover, patients with bicuspid aortic valve and aortic insufficiency had greater increases in annulus ($P < .001$), sinus ($P < .001$), and ascending aorta ($P < .001$) diameters over time.

Conclusions: For patients undergoing the Ross procedure, a combination of bicuspid aortic valves and aortic insufficiency is the main risk factor for late autograft dilatation and dysfunction. (J Thorac Cardiovasc Surg 2018;■:1-8)



Cumulative incidence of autograft reoperation depends on valve anatomy and hemodynamics.

Central Message

Combination of bicuspid aortic valve and aortic insufficiency is the risk factor for late autograft dilatation and dysfunction.

Perspective

The use of the Ross procedure has been limited to relatively few centers. This study showed that patients with bicuspid aortic valves and aortic insufficiency have higher risks of autograft dysfunction and reoperation. These results are useful for selecting patients for the Ross procedure.

Factors impacting long-term pulmonary autograft durability after the Ross procedure

Ravil Sha… …ID,
Alexey Pi…

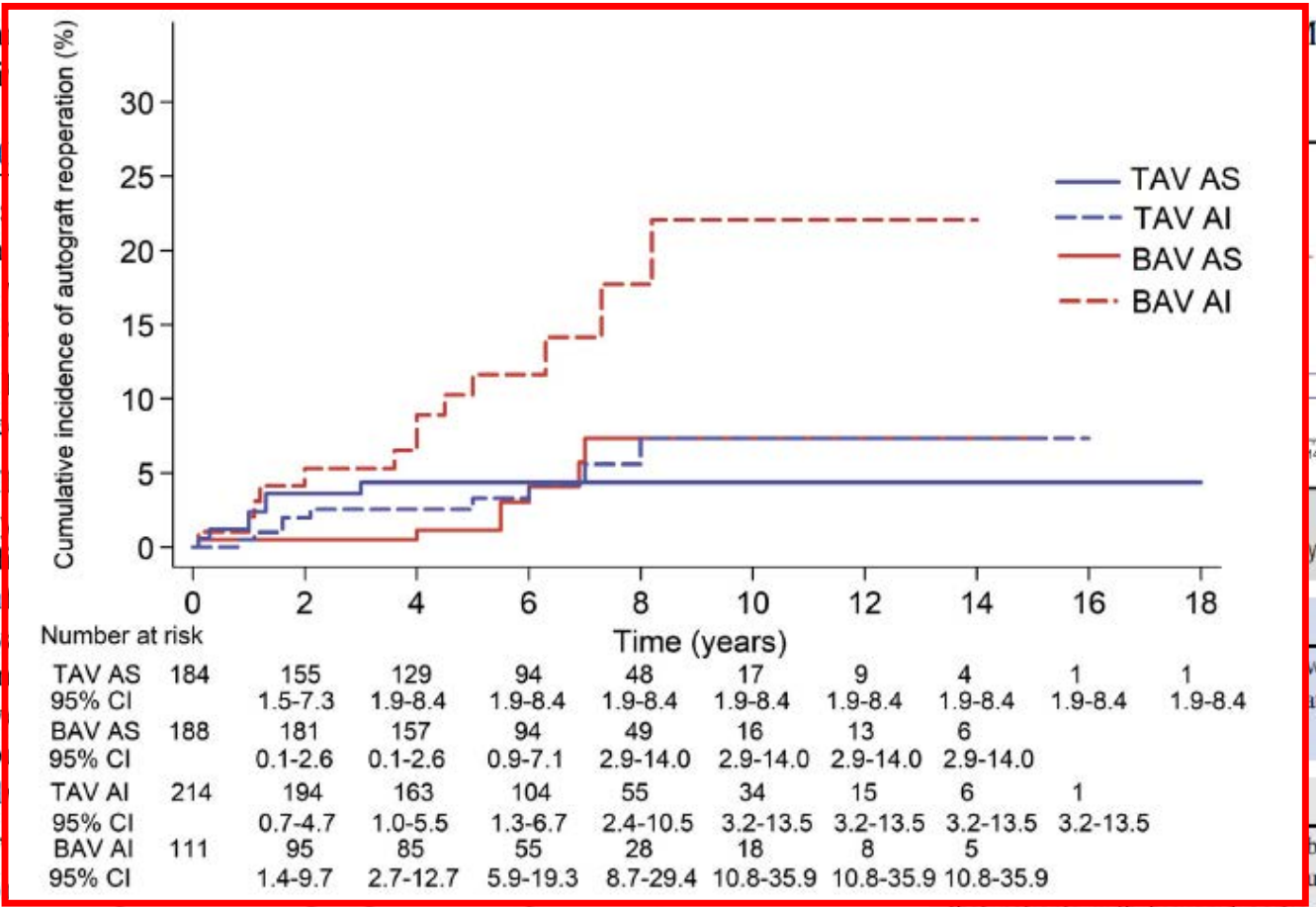
ABSTRA…

Objective: …and a high… this study, … predictors …

Methods: … Ross proce…

Results: T… 6.5 ± 3.2 … effects ord… aortic insu… autograft v… reoperatio… aortic valv… (subdistrib… aortic val… ($P < .001$).

Conclusio… bicuspid aortic valves and aortic insufficiency is the main risk factor for late autograft dilatation and dysfunction. (J Thorac Cardiovasc Surg 2018;■:1-8)



…reoperation …ynamics.

…e and aortic …ate autograft

…been limited …udy showed

that patients with bicuspid aortic valves and aortic insufficiency have higher risks of autograft dysfunction and reoperation. These results are useful for selecting patients for the Ross procedure.

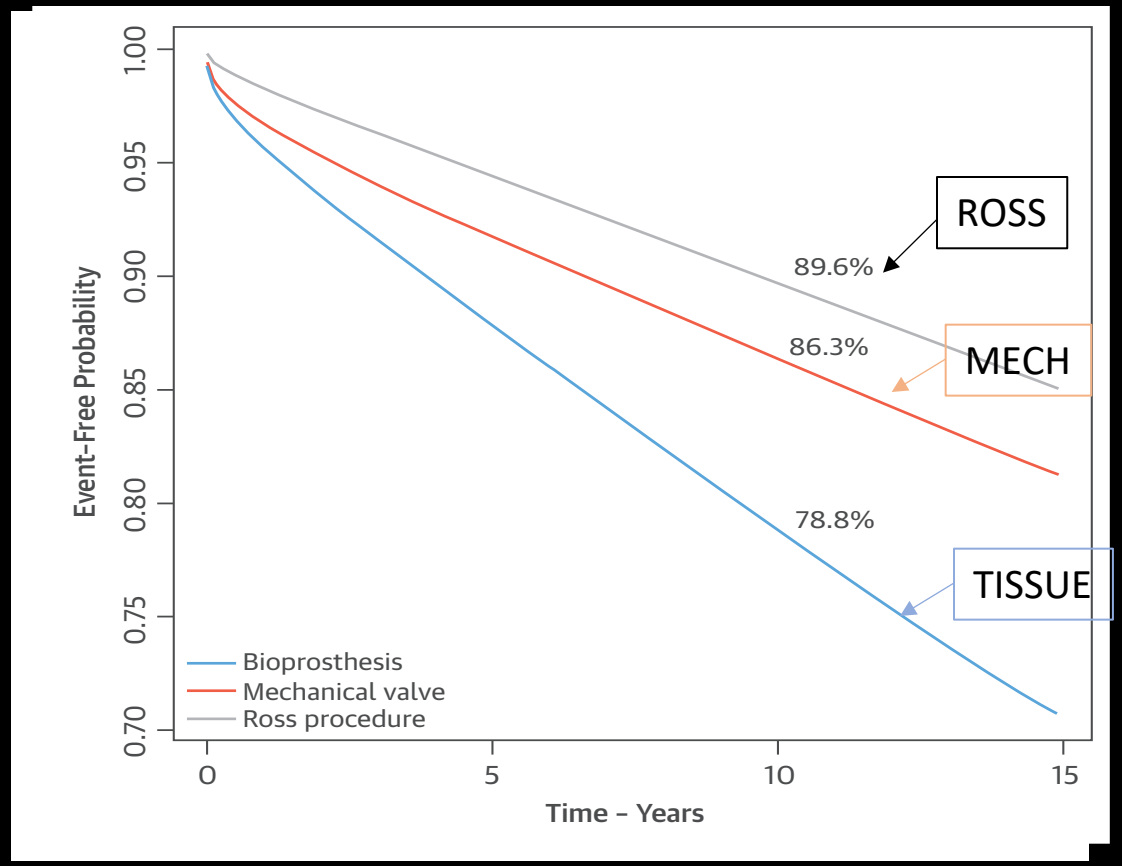
Survival Free from Reoperation

Aortic Valve Replacement and the Ross Operation in Children and Young Adults

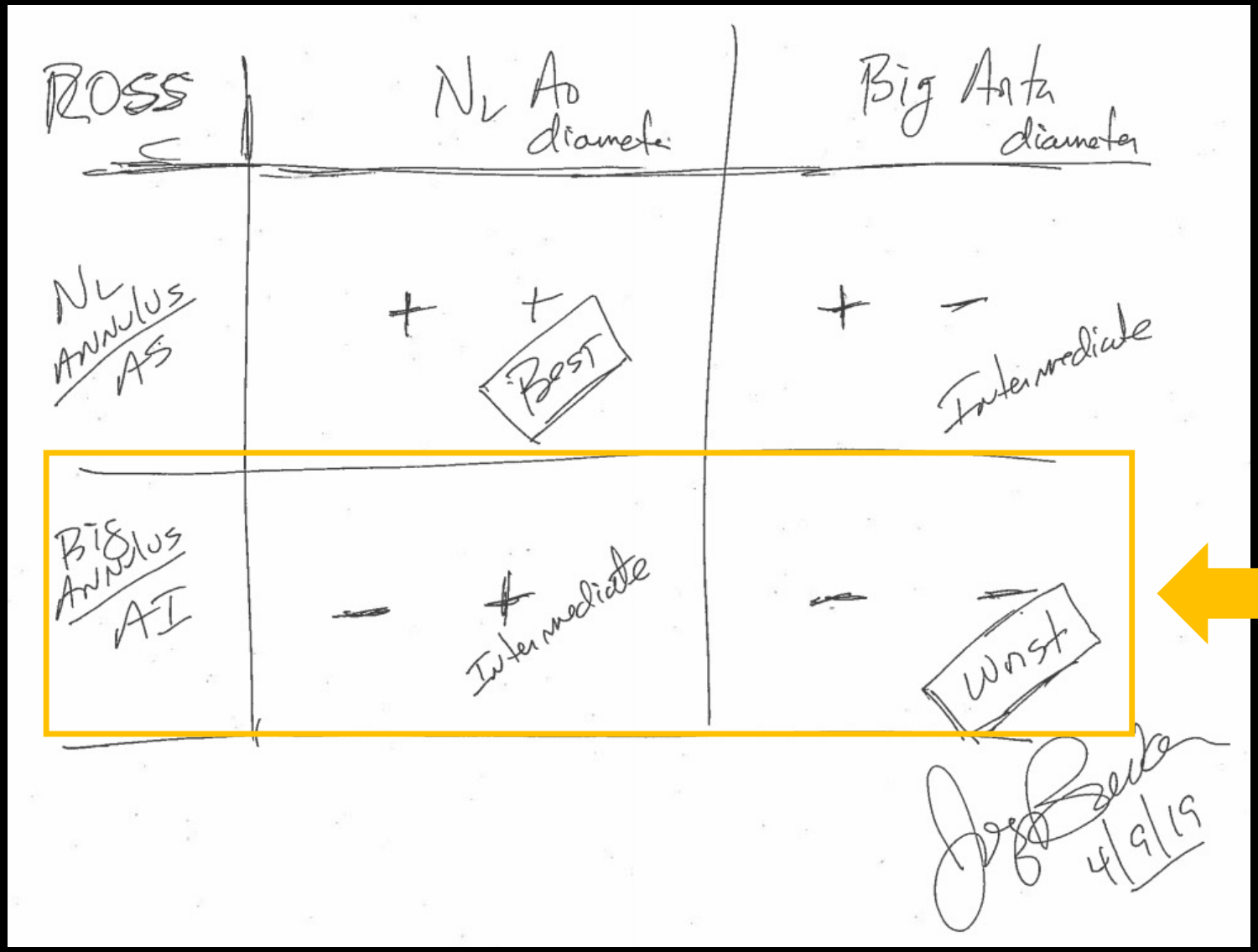
Mansour T.A. Sharabiani, PhD,[a] Dan M. Dorobantu, MD,[b,c] Alireza S. Mahani, PhD,[d] Mark Turner, PhD,[b] Andrew J. Peter Tometzki, MBChB,[b] Gianni D. Angelini, MD,[a,b] Andrew J. Parry, MBChB,[b] Massimo Caputo, MD,[b] Serban C. Stoica, MD[b]

- **UK National Registry**
- 2000-2012
- **1501 patients**

- **~1% per yr reop rate for AS**
- **~2% per yr reop rate for AI**



The indication for which you do a Ross matters



AV Repair +/- aortic replacement

OR

Supported Ross

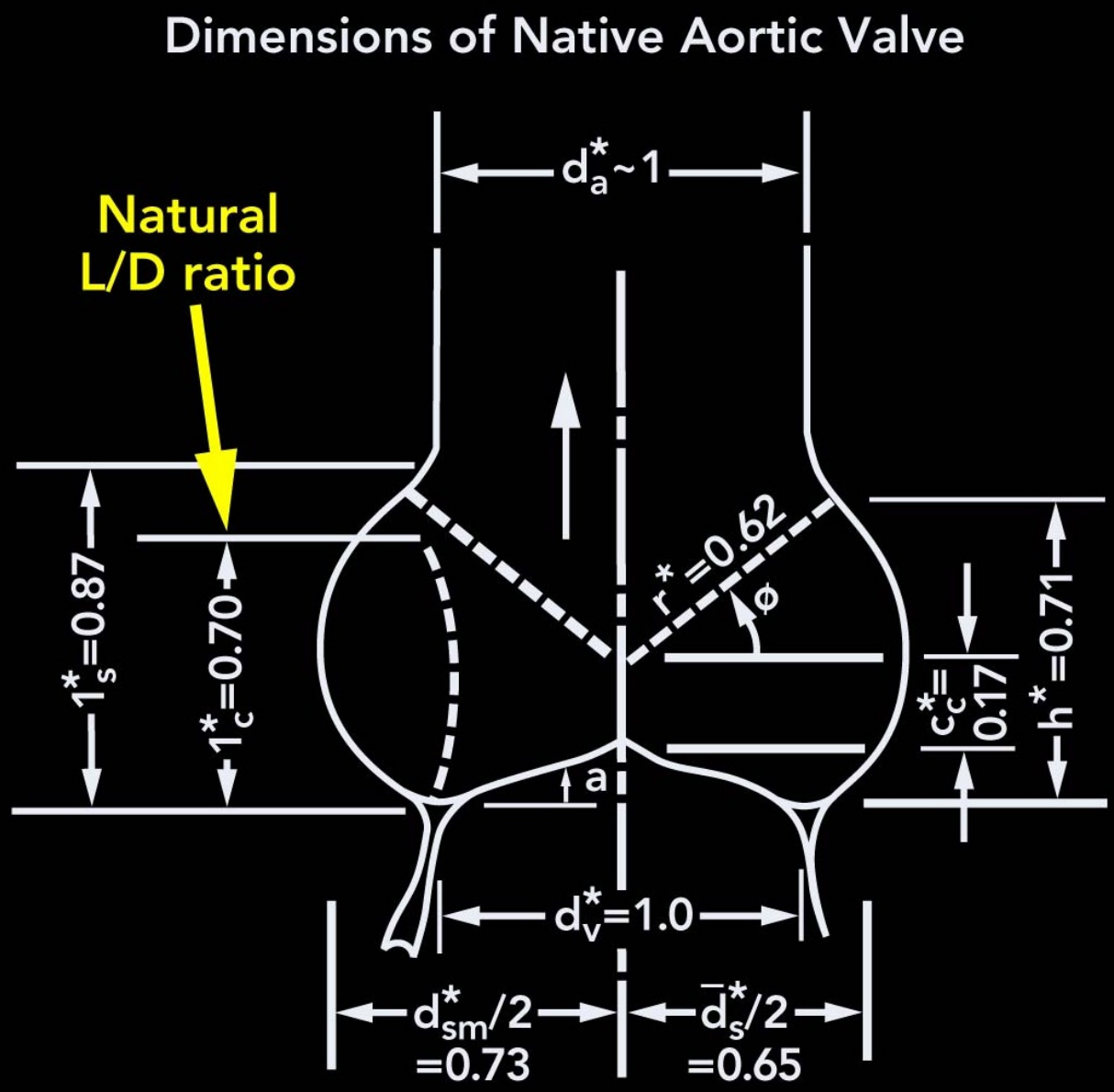
Current Needs

- Better informed indications for intervention / guidelines
- Better biomaterials for valve repair
- Better valve prostheses (durable, growth, no anticoagulation)
- More rapid approval of new devices

Take Home Points

- Valve repair best option in AI
  - IF: Durable repair feasible (i.e. favorable morphology)
- Ross is a “gold standard” option, especially in AS
  - IF: Surgeon is experienced and Center is experienced
  - In AI: Adjunctive techniques to support autograft helpful
- Ozaki reserved for very limited circumstances, for example, when Ross not possible (i.e. Truncus)
- Mechanical AVR or Tissue AVR as a third option

Thank You!


Dimensions of Native Aortic Valve
Natural
L/D ratio
d_a^*~1
l_s^*=0.87
l_c^*=0.70
r^*=0.62
ϕ
c_c^*=0.17
h^*=0.71
a
d_v^*=1.0
$d_{sm}^*/2$
=0.73
$\bar{d}_s^*/2$
=0.65