Ross or No Ross?

Ismail El-Hamamsy, MD PhD

Associate Professor
Division of Cardiac Surgery
Co-Director, Aortic and Connective Tissue Clinic
Montreal Heart Institute
Université de Montreal

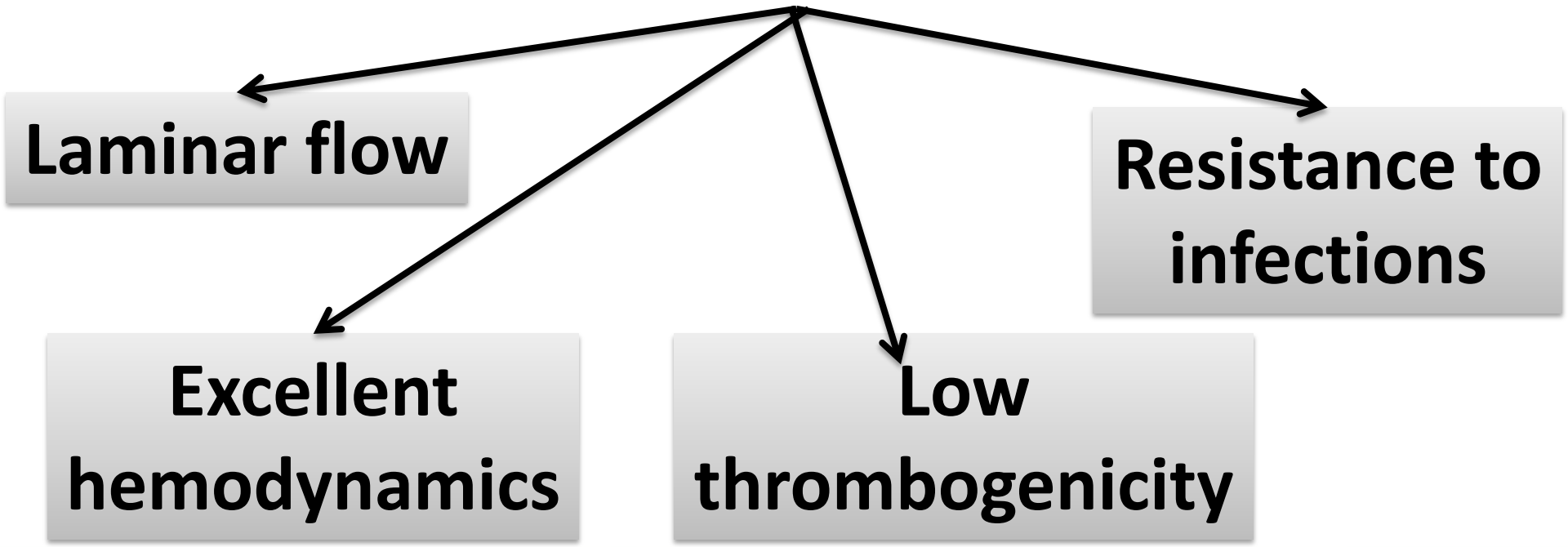
-1-

THE AORTIC ROOT IS

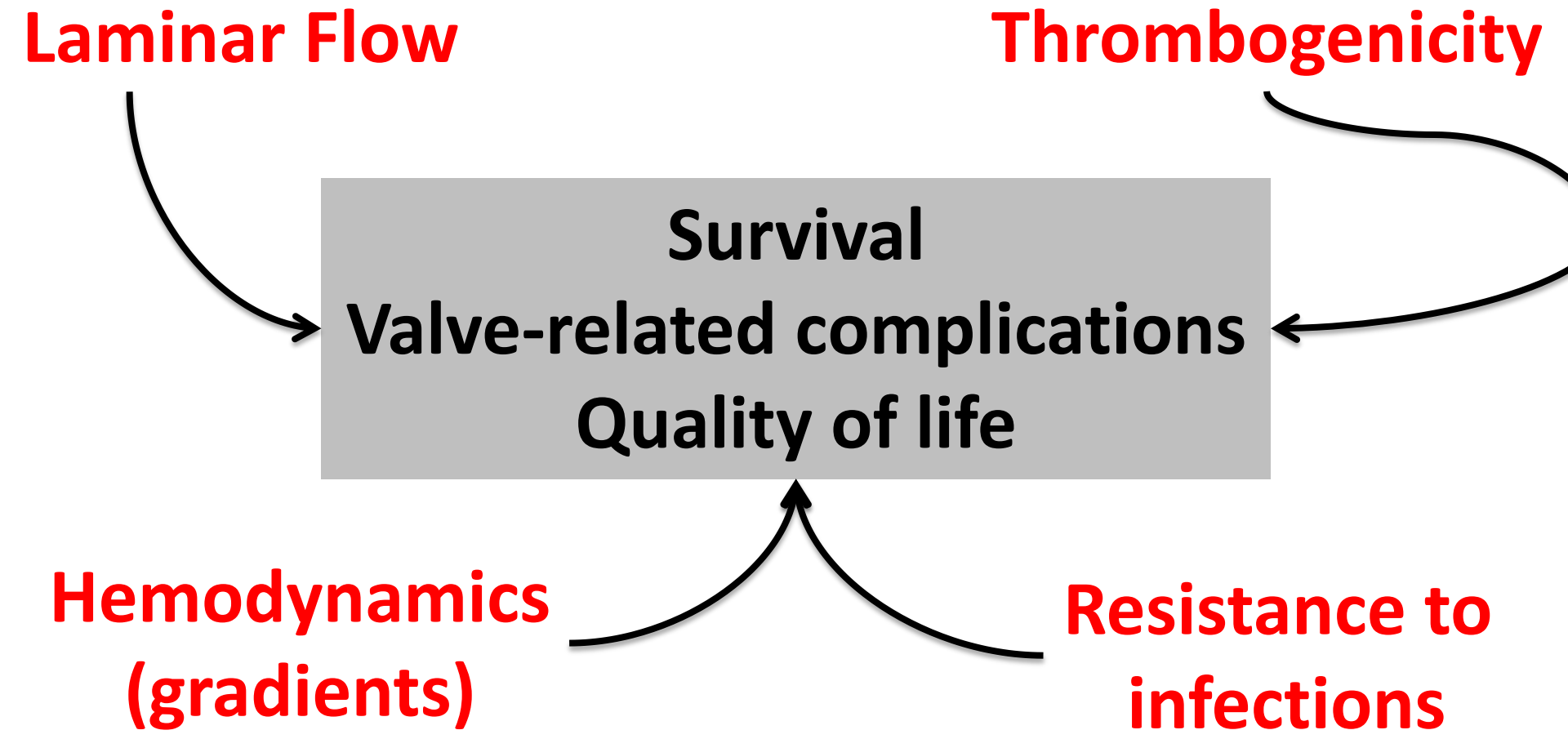
A LIVING STRUCTURE

THE AORTIC ROOT

LIVING STRUCTURE
=
COMPLEX FUNCTIONS



OUTCOMES FOLLOWING AVR



Rationale

A LIVING AORTIC VALVE SUBSTITUTE

IMPROVED CLINICALLY-RELEVANT OUTCOMES

-2-

CONVENTIONAL AVR IN THE YOUNG

=

EXCESS MORTALITY

Historical Perspective

to the drugs being used in efforts to control the outbreak. The extent of the problem may be gauged from the fact that in the comparatively limited outbreak described, strains with eight different patterns of drug resistance, from full sensitivity to resistance to six different antimicrobial agents, were isolated, and that the interaction of at least three different R factors, conferring resistance to

REPLACEMENT OF AORTIC AND MITRAL VALVES WITH A PULMONARY AUTOGRAFT

DONALD N. ROSS
M.B., B.Sc. Cape Town, F.R.C.S.
CONSULTANT THORACIC SURGEON, GUY'S HOSPITAL, LONDON S.E.1, AND NATIONAL HEART HOSPITAL, LONDON W.1

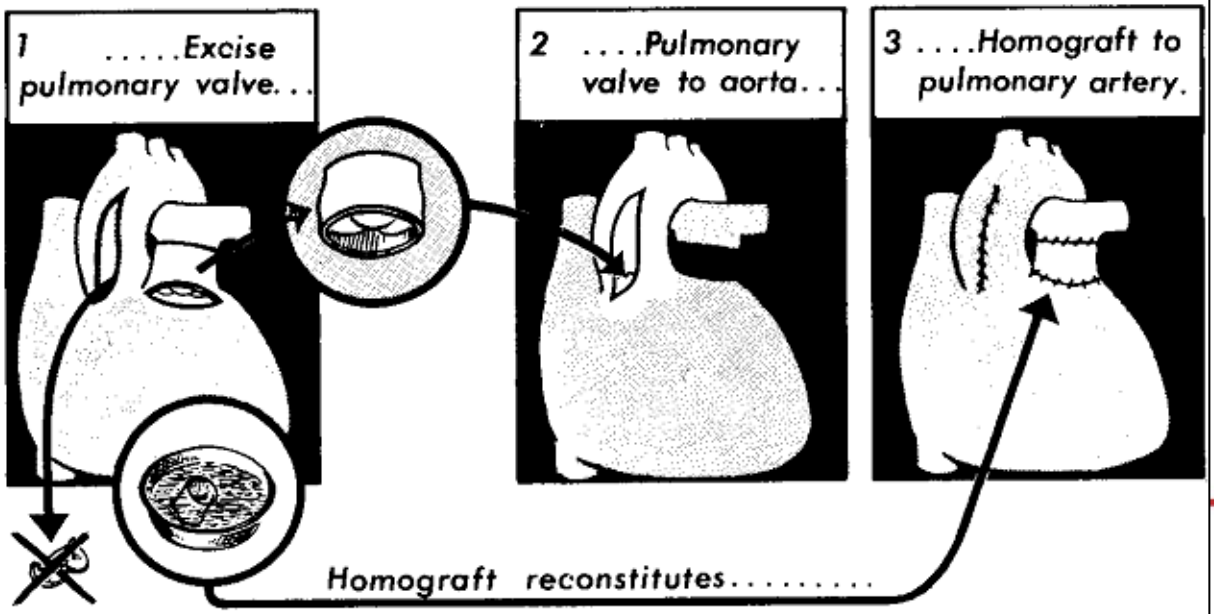
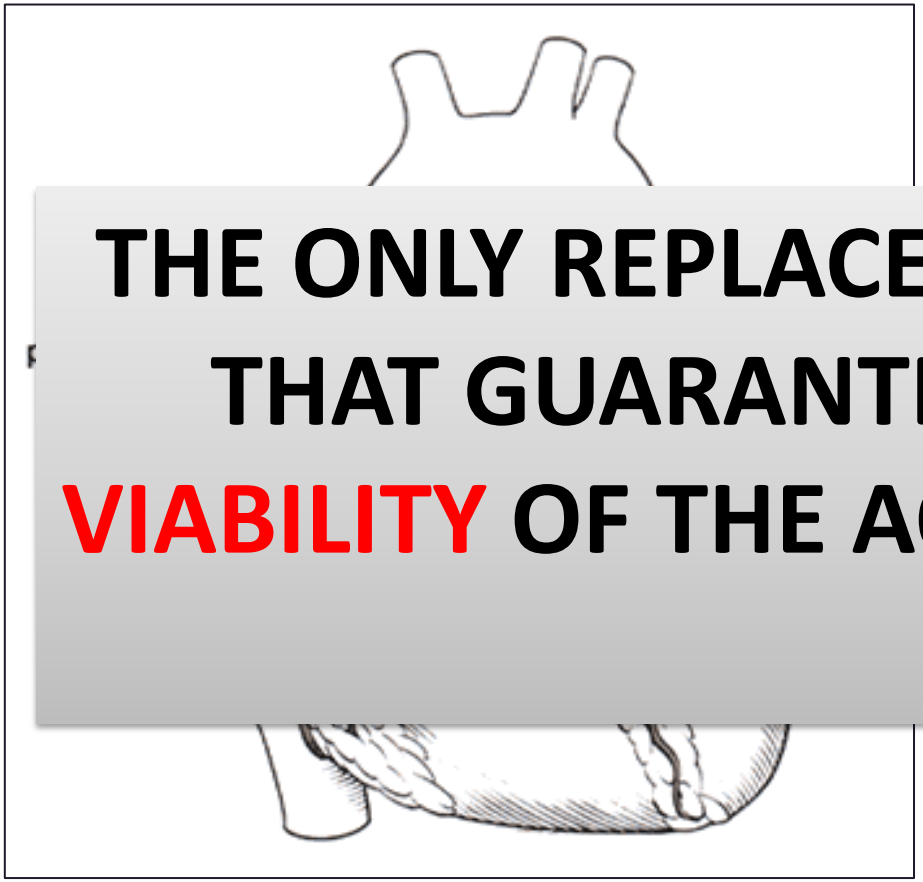
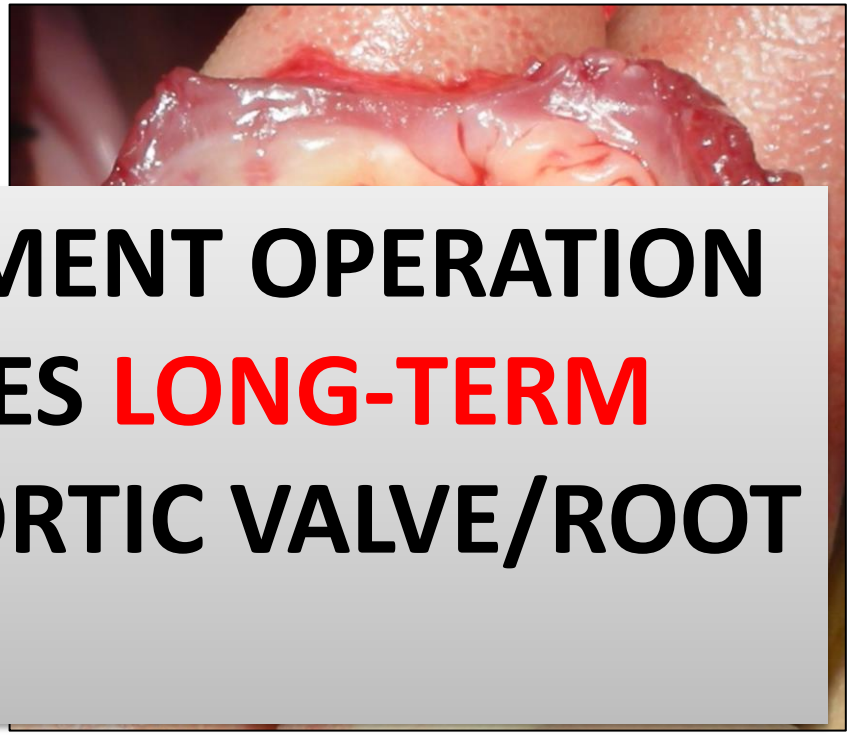


Fig. 3—Steps in replacement of aortic valve with a pulmonary autograft.

ROSS PROCEDURE





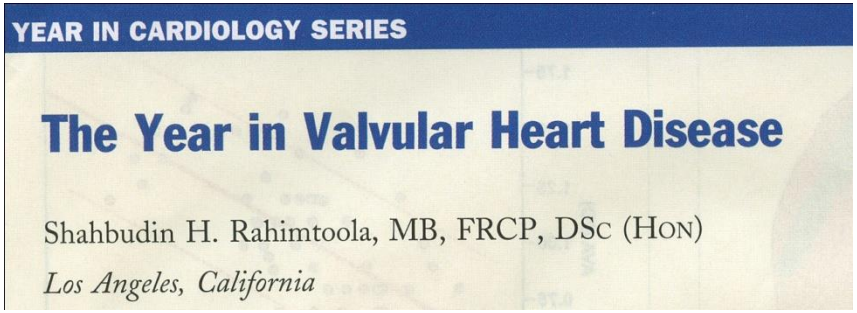
THE ONLY REPLACEMENT OPERATION THAT GUARANTEES LONG-TERM VIABILITY OF THE AORTIC VALVE/ROOT

-3-

ROSS PROCEDURE =

IMPROVED CLINICAL OUTCOMES

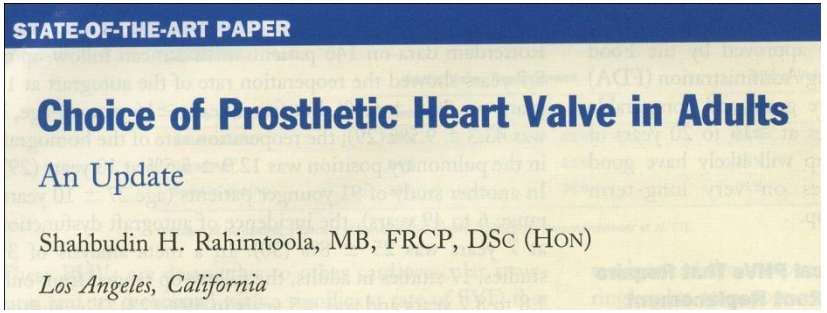
Negative Biases


YEAR IN CARDIOLOGY SERIES

The Year in Valvular Heart Disease

Shahbudin H. Rahimtoola, MB, FRCP, DSc (Hon)

Los Angeles, California


STATE-OF-THE-ART PAPER

Choice of Prosthetic Heart Valve in Adults

An Update

Shahbudin H. Rahimtoola, MB, FRCP, DSc (Hon)

Los Angeles, California

"Transforms single valve disease into double valve disease"

"High operative morbidity and mortality"

"High rate of reoperations"

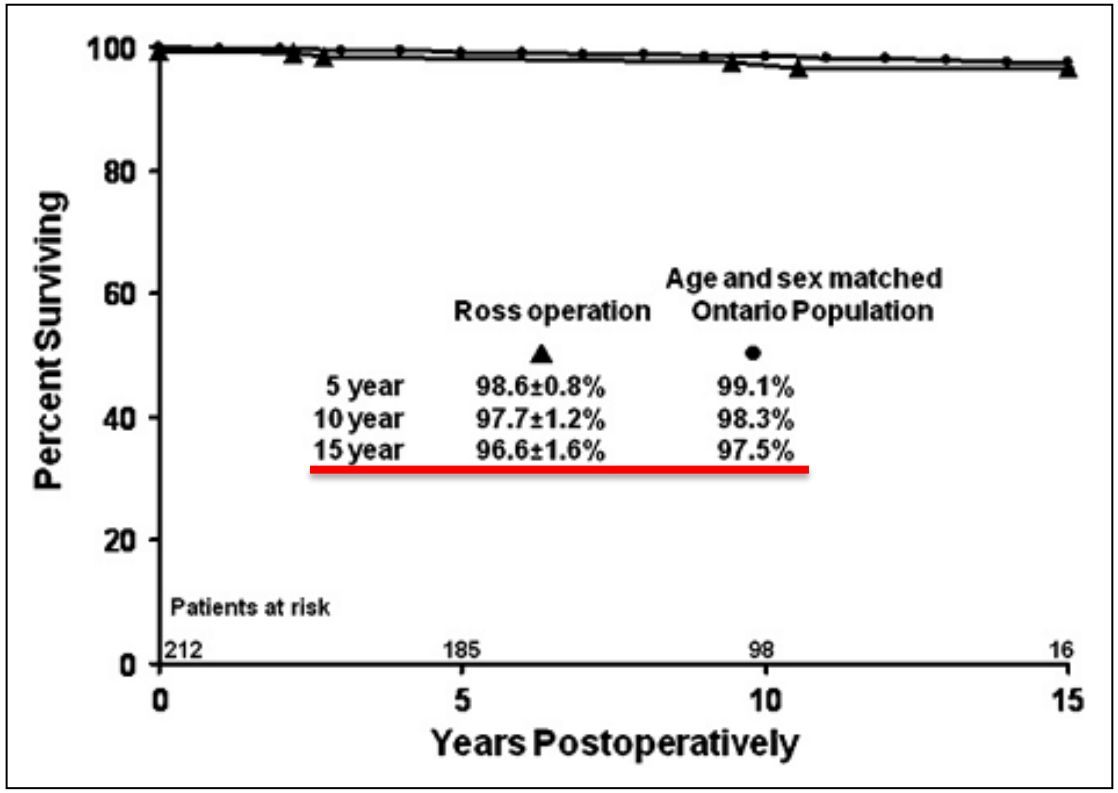
SURVIVAL

SURVIVAL - ROSS

When is the Ross operation a good option to treat aortic valve disease?

Tirone E. David, MD, Anna Woo, MD, Susan Armstrong, MSc, and Manjula Maganti, MSc

- 1990-2004
- **212 pts**
- **34 +/- 9 years**
- **Mean Fup: 10.1 years**



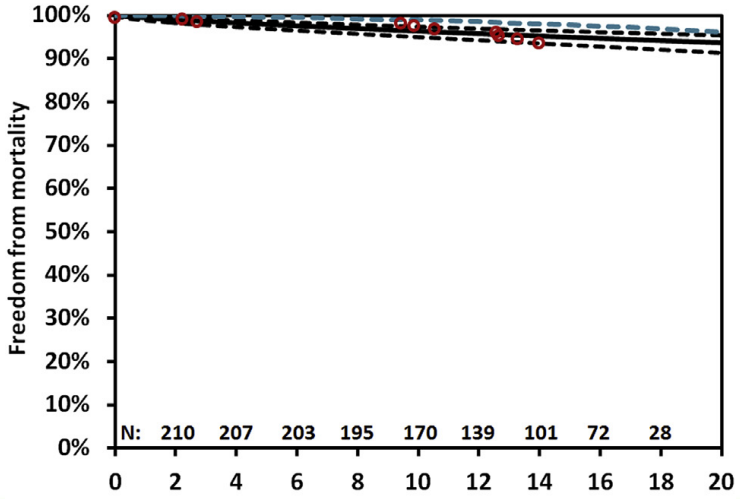
David et al. JTCVS 2010

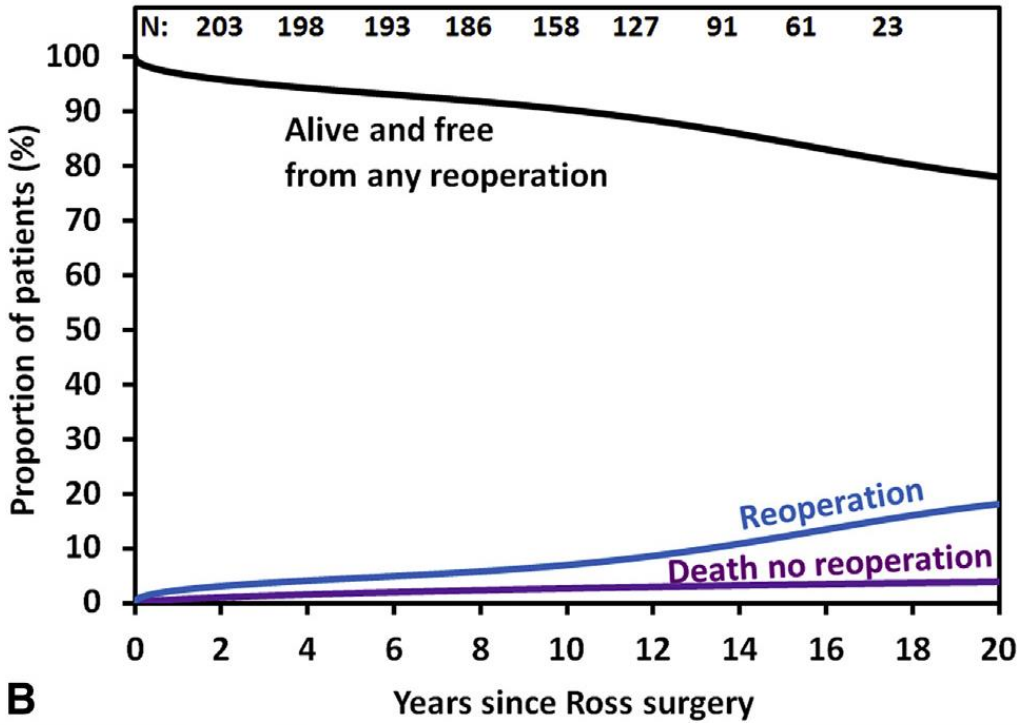
SURVIVAL - ROSS

The Ross procedure: Outcomes at 20 years

Tirone E. David, MD, Carolyn David, BN, Anna Woo, MD, and Cedric Manlhiot, BSc

- 1990-2004
- **212 pts**
- **34 +/- 9 years**
- **Median Fup: 13.8 years**



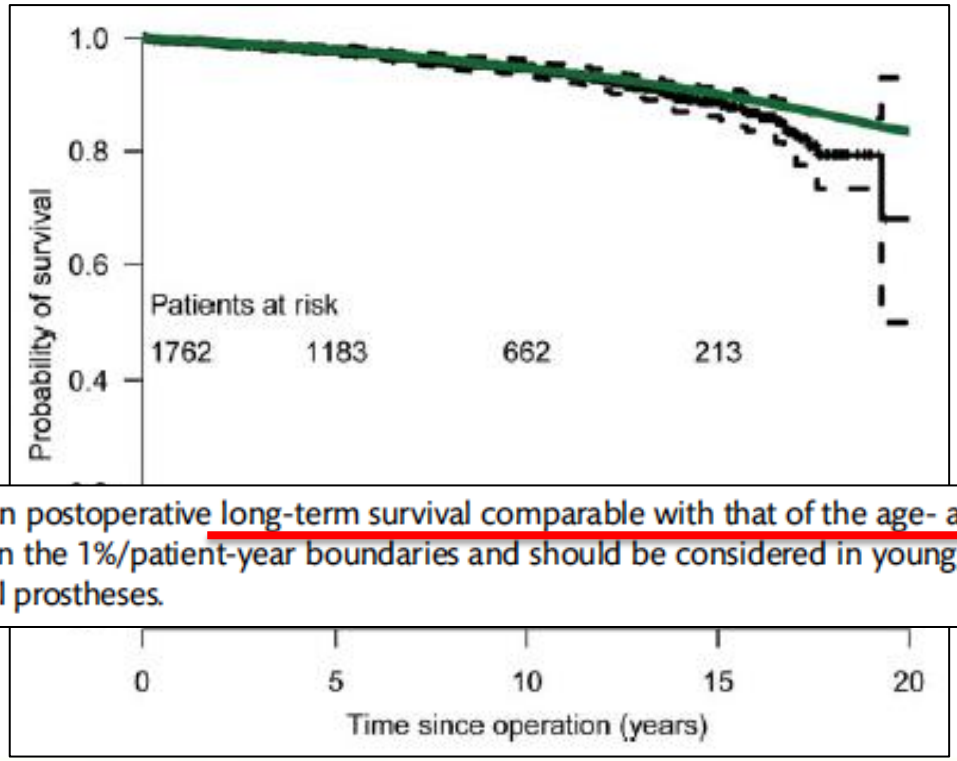


David et al. JTCVS 2014

SURVIVAL

A multicentre evaluation of the autograft procedure for young patients undergoing aortic valve replacement: update on the German Ross Registry†

- 1990-2013
- **1779 pts (8 centers)**
- **45+/- 11 years**
- **Mean Fup: 8.3 years (662 pts >10 years)**



CONCLUSION: The autograft principle results in postoperative long-term survival comparable with that of the age- and gender-matched general population and reoperation rates within the 1%/patient-year boundaries and should be considered in young, active patients who want to avoid the shortcomings of conventional prostheses.

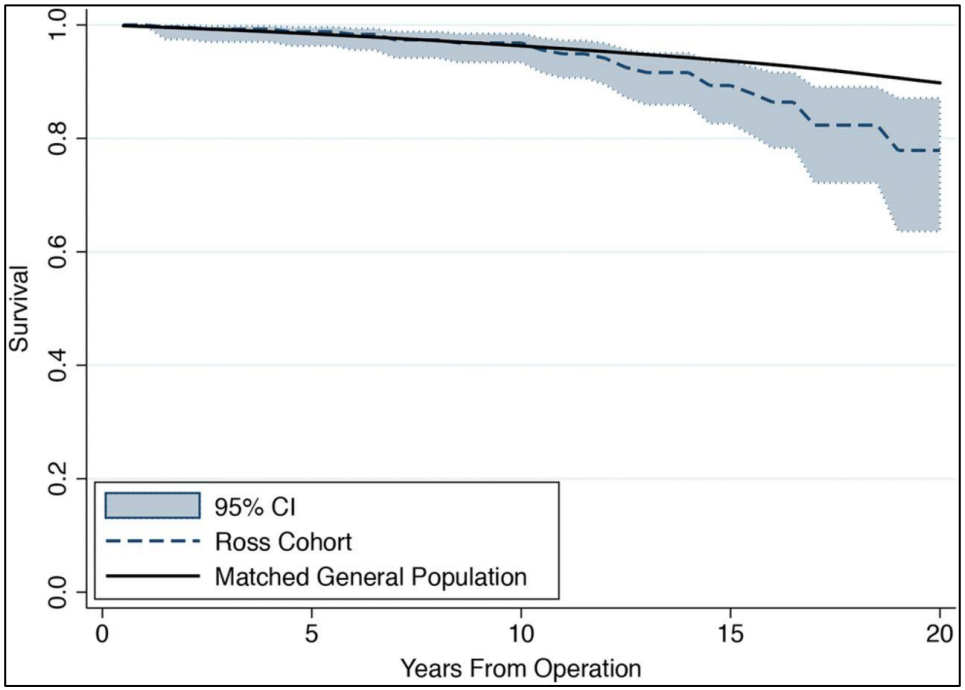
Sievers et al. Eur J Cardiothor Surg 2015

SURVIVAL

The Ross procedure in young adults: over 20 years of experience in our Institution†

Stefano Mastrobuoni*, Laurent de Kerchove, Silvia Solari, Parla Astarci, Alain Poncelet, Philippe Noirhomme, Jean Rubay and Gebrine El Khoury

- 1991-2014
- **306 pts**
- **42+/- 9 years**
- **Median Fup: 10.6 years**



Mastrobuoni, Eur J Cardiothorac Surg, 2015

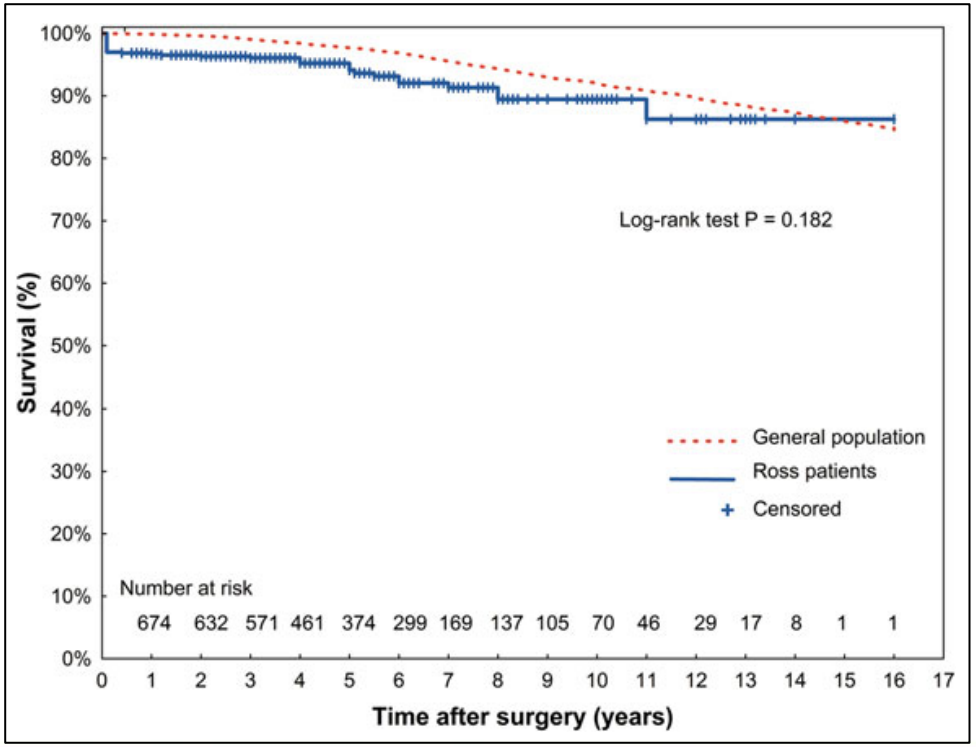
INSTITUT DE CARDIOLOGIE DE MONTRÉAL

Université de Montréal

Results of the Ross procedure in adults: a single-centre experience of 741 operations†

Alexander Karaskov, Ravil Sharifulin*, Sergey Zheleznev, Igor Demin, Evgeny Lenko and Alexander Bogachev-Prokophiev

- 1998-2014
- **741 pts**
- **47 +/- 13 years**
- **Median Fup: 5.8 years**



Karaskov et al., Eur J Cardiothorac Surg, 2016

SURVIVAL - ROSS

Long-term outcomes after autograft versus homograft aortic root replacement in adults with aortic valve disease: a randomised controlled trial

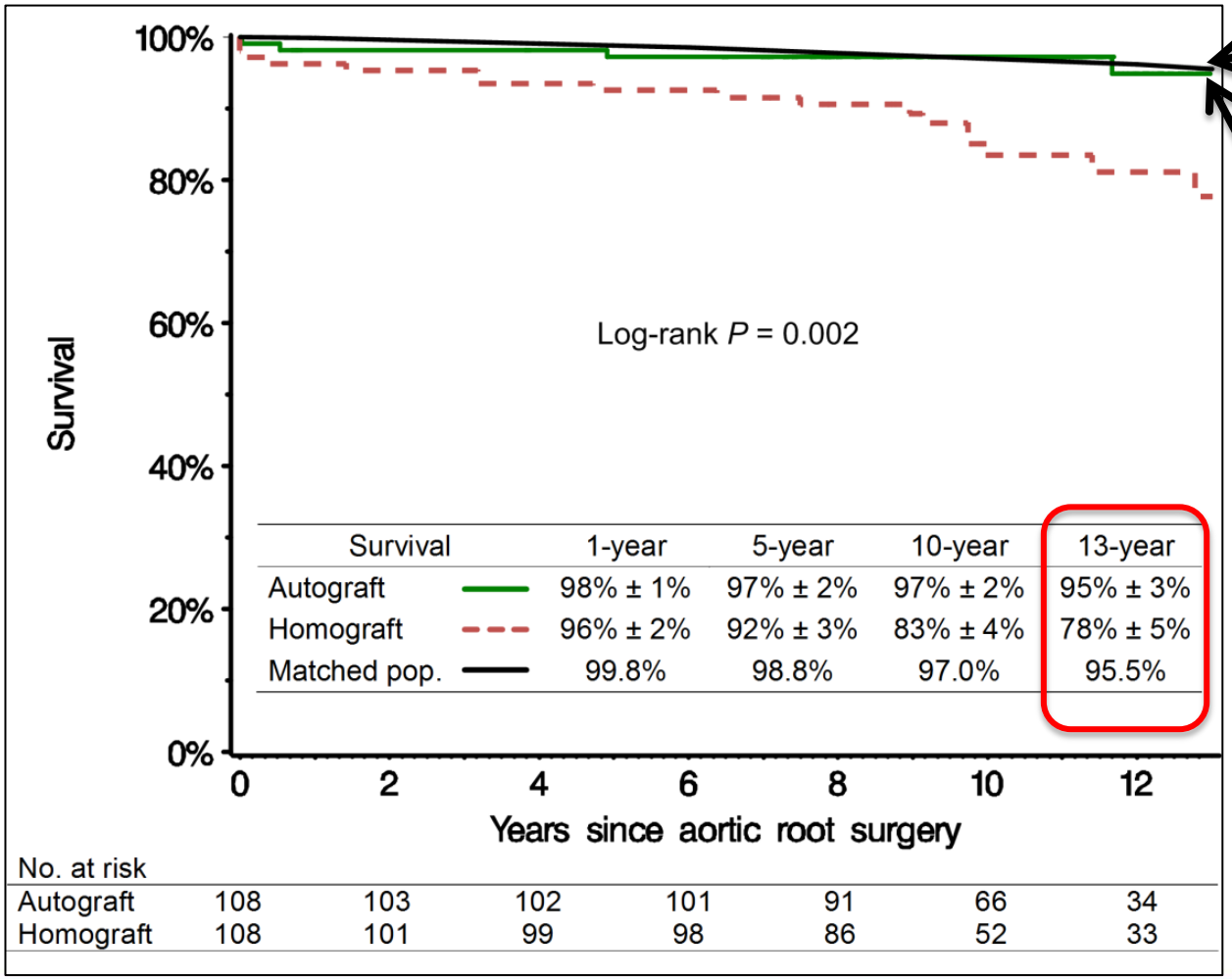
Ismail El-Hamamsy, Zeynep Eryigit, Louis-Mathieu Stevens, Zubair Sarang, Robert George, Lucy Clark, Giovanni Melina, Johanna J M Takkenberg, Magdi H Yacoub

	Homograft (n=108)	Autograft (n=108)
Age (years; median, range)	39 (19–68)	38 (19–66)
Endocarditis		
None	86 (80%)	89 (82%)
Active	9 (8%)	9 (8%)
Treated	13 (12%)	10 (9%)
Smoker	23 (21%)	18 (17%)
Previous intervention†	48 (44%)	45 (42%)
Homograft	33 (31%)	24 (22%)
Mechanical or tissue prosthesis	12 (11%)	13 (12%)
Aortic valve repair	9 (8%)	12 (11%)
Coarctation repair	2 (2%)	9 (8%)
2	16 (15%)	21 (19%)
3	28 (26%)	34 (31%)
4	44 (41%)	44 (41%)

	Homograft (n=108)	Autograft (n=108)
(Continued from previous page)		
Rheumatic	6 (6%)	7 (6%)
II	48 (44%)	49 (45%)
III	29 (27%)	21 (19%)
IV	9 (8%)	5 (5%)

El-Hamamsy et al. Lancet 2010

SURVIVAL - ROSS



Survival	1-year	5-year	10-year	13-year
Autograft	98% ± 1%	97% ± 2%	97% ± 2%	95% ± 3%
Homograft	96% ± 2%	92% ± 3%	83% ± 4%	78% ± 5%
Matched pop.	99.8%	98.8%	97.0%	95.5%

No. at risk							
Autograft	108	103	102	101	91	66	34
Homograft	108	101	99	98	86	52	33

El-Hamamsy et al. Lancet 2010

Survival - Ross

The Ross Procedure
A Systematic Review and Meta-Analysis

Johanna J.M. Takkenberg, MD, PhD; Loes M.A. Klieverik, MD, PhD; Paul H. Schoof, MD, PhD; Robert-Jan van Suylen, MD, PhD; Lex A. van Herwerden, MD, PhD; Pieter E. Zondervan, MD, PhD; Jolien W. Roos-Hesselink, MD, PhD; Marinus J.C. Eijkemans, PhD; Magdi H. Yacoub, MD, PhD; Ad J.J.C. Bogers, MD, PhD

5,031 adults, children; 2000-2008

"Late mortality rates are low and resemble the adult series age-matched population mortality."

Takkenberg et al. Circulation 2009

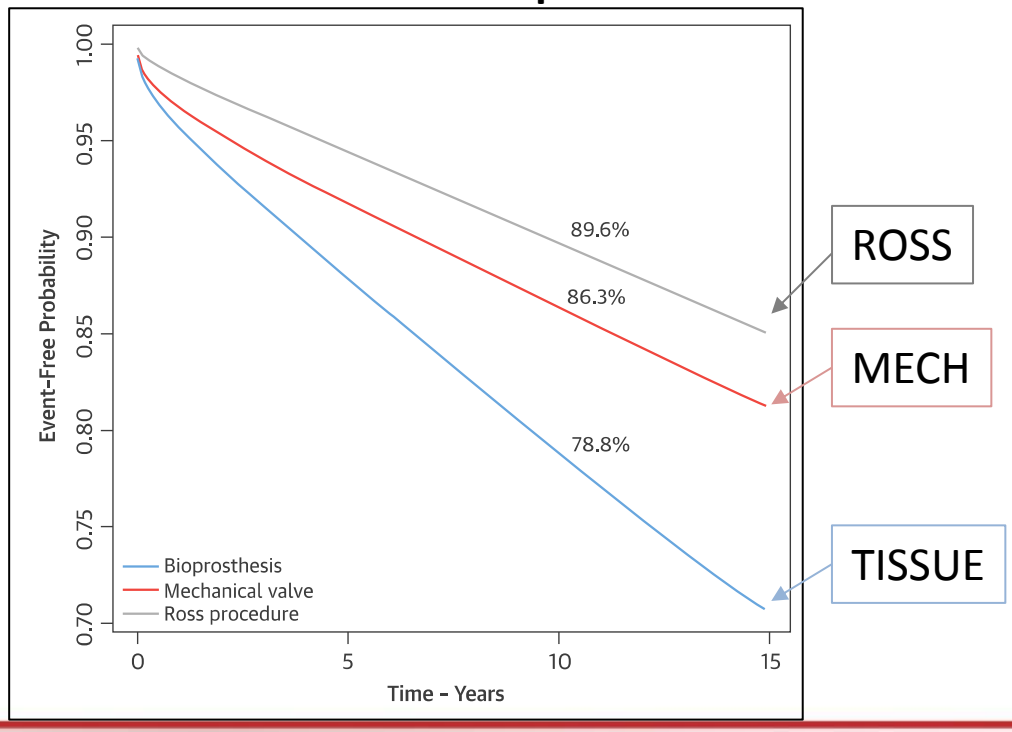
Survival Free from Reoperation

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**

Survival free from reoperation



Sharabiani et al. JACC 2016

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

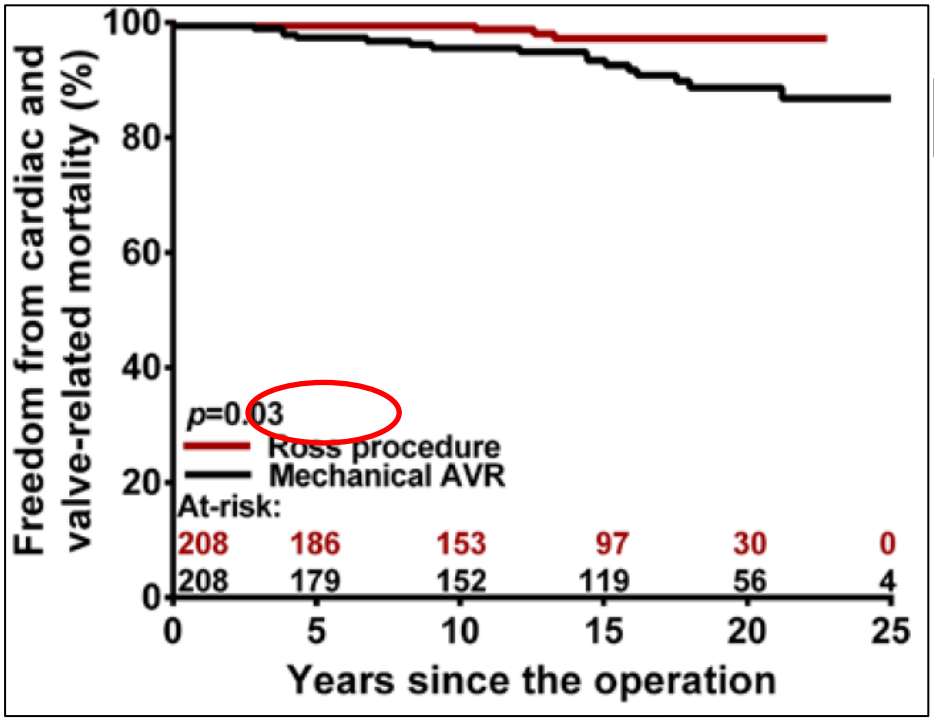
Université de Montréal

Ross vs. Mechanical AVR

Long-Term Outcomes of the Ross Procedure Versus Mechanical Aortic Valve Replacement

Propensity-Matched Cohort Study

Amine Mazine, MD, MSc
Tirone E. David, MD
Vivek Rao, MD, PhD
Edward J. Hickey, BM
Shakira Christie, BSc
Cedric Manlhiot, PhD
Maral Ouzounian, MD, PhD



Ross

Mechanical

LATE SURVIVAL - ROSS

Study	Study Type	Study Period	N	Mean Follow-up (years)	Mean Age (years)	BAV (%)	AS (%) / AI (%) / Mixed AS-AI (%)	Operative mortality (%)	5-Year Survival (%)	10-Year Survival (%)	15-Year Survival (%)
El-Hamamsy et al. (2010)	RCT	1994-2001	216 pts (108 Ross)	10.2 (2173 pt-yrs)	38	49%	28% 45% 27%	0.9%	97%	97%	95%**
Sievers et al. (2015)	Multicenter Ross Registry (prospective)	1990-2013	1779	8.3 (14,288 pt-yrs)	44.7	64.8%	24% 22% 52%	1.1%	NA	NA	90%**
David et al. (2014)	Single center	1990-2004	212	13.8*	34	71.7%	50% 36% 13%	0.4%	98.6%	97.5%	93.6%**
Mastrobuoni et al. (2015)	Single center	1991-2014	306	10.6*	42	58.5%	68% 31% 0%	2.3%	NA	NA	88%**
Skillington et al. (2013)	Single center	1992-2012	310	9.4	39.3	92%	46% 32% 22%	0.3%	98%	98%	97%**
Da Costa et al. (2014)	Single center	1995-2013	414	8,2	30.8	50%	29% 39% 31%	2.7%	NA	NA	89.3%**
Kalfa et al. (2015)	Single center	1990-2013	221	11.4*	41.5	76.5%	81% 0% 19%	0.9%	NA	92%	90.5%
Andreas et al. (2014)	Single center	1991-2011	246	10*	29	75%	29% 40% 31%	1.6%	96%	94%	91%**

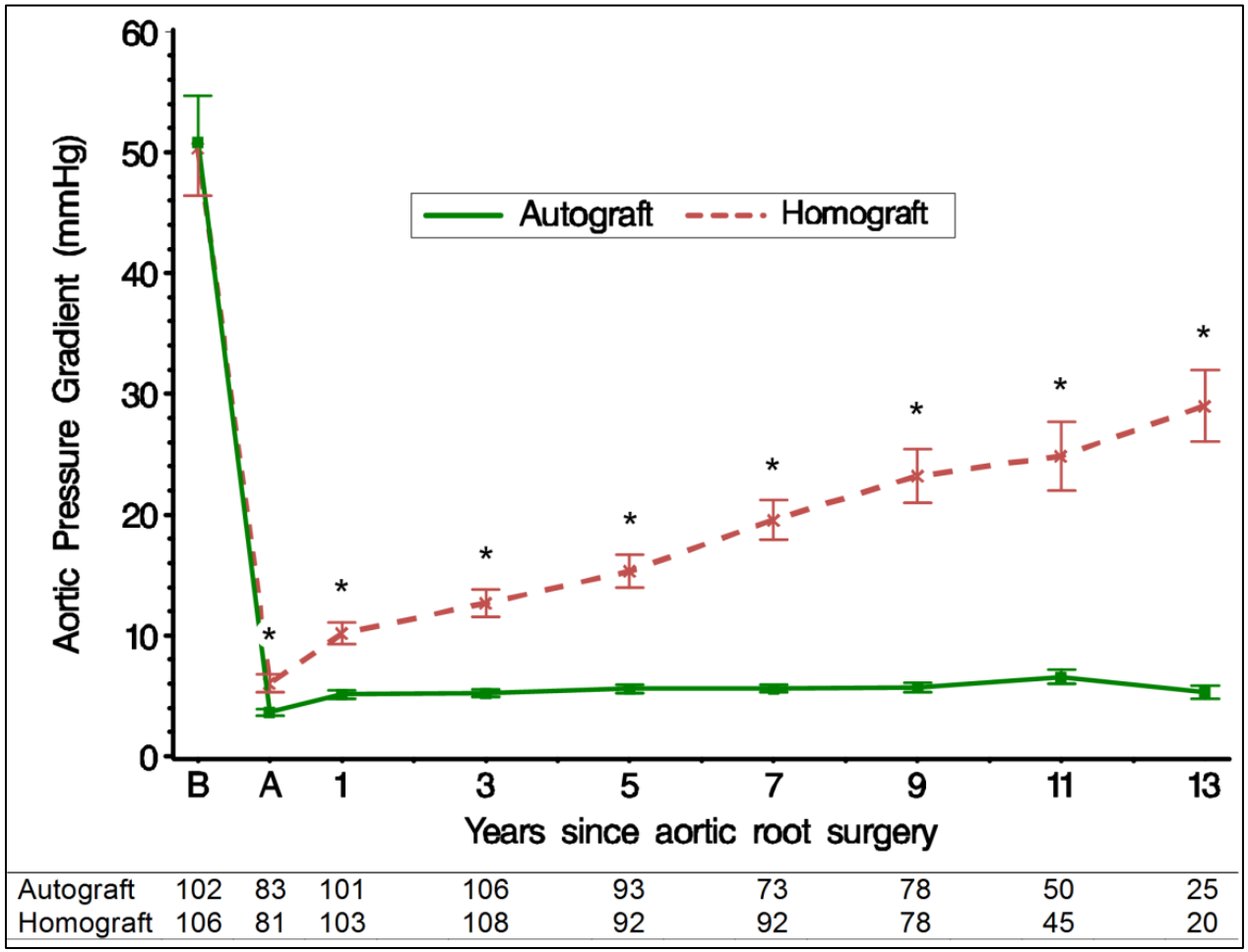
>3600 pts

THE ROSS PROCEDURE

THE ONLY REPLACEMENT OPERATION THAT RESTORES LONG-TERM SURVIVAL FOLLOWING AORTIC VALVE REPLACEMENT

Hemodynamics (Exercise capacity)

Long-Term Hemodynamics



Autograft	102	83	101	106	93	73	78	50	25
Homograft	106	81	103	108	92	92	78	45	20

El-Hamamsy et al. Lancet 2010

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

Université de Montréal

Aortic Gradients with Exercise

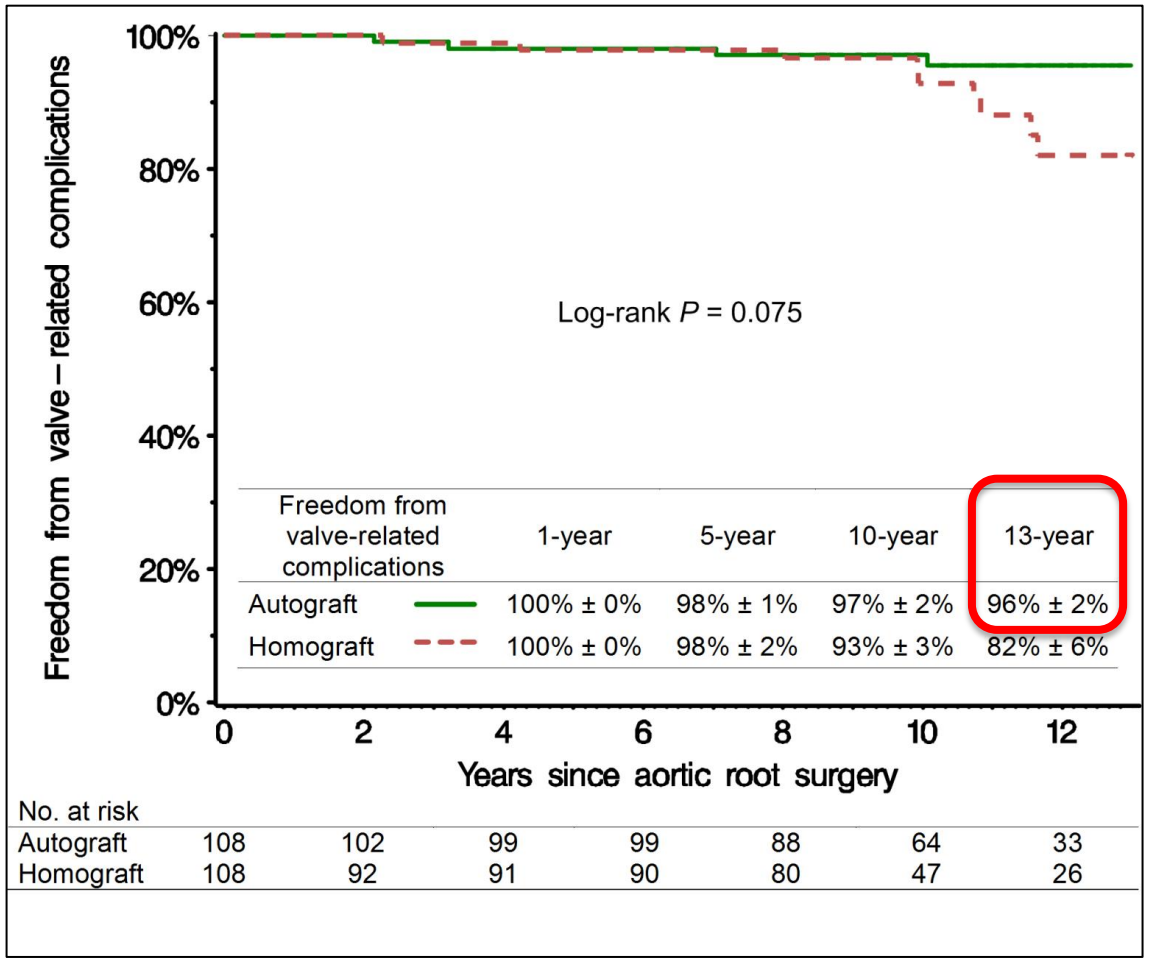
TABLE 3 Change in Aortic Valve Hemodynamics With Exercise in Ross Subjects and in Healthy Control Subjects

	Baseline (rest upright)	50-W Exercise	Change With 50-W Exercise	Maximum Exercise	Change With Maximum Exercise	p Value Exercise Effect
Cardiac index (L/min/m^2)						<0.001
Ross (n = 19)	2.95 ± 0.68	4.87 ± 1.18†	+1.92 ± 0.69†	6.46 ± 1.54†	+3.51 ± 1.18†	
Control (n = 12)	2.50 ± 0.31	4.35 ± 0.45†	+1.85 ± 0.34†	6.81 ± 1.80†	+4.32 ± 1.74†	
Mean transvalvular flow rate (ml/s)						<0.001
Ross (n = 19)	271 ± 58	363 ± 89†	+91 ± 52†	443 ± 129†	+172 ± 86†	
Control (n = 12)	271 ± 48	351 ± 60*	+80 ± 43*	489 ± 126†	+217 ± 98†	
Effective orifice area (cm^2)						NS
Ross (n = 19)	3.57 ± 0.82	3.61 ± 0.82	+0.04 ± 0.26	3.59 ± 0.90	+0.05 ± 0.42	
Control (n = 12)	3.47 ± 0.71	3.49 ± 0.68	+0.02 ± 0.26	3.58 ± 0.80	+0.12 ± 0.37	
Indexed effective orifice area (cm^2/m^2)						NS
Ross (n = 19)	1.94 ± 0.43	1.96 ± 0.43	+0.02 ± 0.14	1.95 ± 0.46	+0.02 ± 0.22	
Control (n = 12)	1.80 ± 0.30	1.82 ± 0.28	+0.01 ± 0.13	1.87 ± 0.34	+0.06 ± 0.19	
Peak gradient (mm Hg)						<0.001
Ross (n = 19)	2 ± 1	3 ± 3	+2 ± 2	6 ± 5†	+4 ± 5†	
Control (n = 12)	2 ± 1	4 ± 2	+2 ± 1	6 ± 5†	+4 ± 5†	
Mean gradient (mm Hg)						<0.001
Ross (n = 19)	1 ± 1	2 ± 1	+1 ± 1	3 ± 2†	+2 ± 2†	
Control (n = 12)	1 ± 1	2 ± 1	+1 ± 1	3 ± 3†	+2 ± 3†	

Pibarot et al. AJC 2000

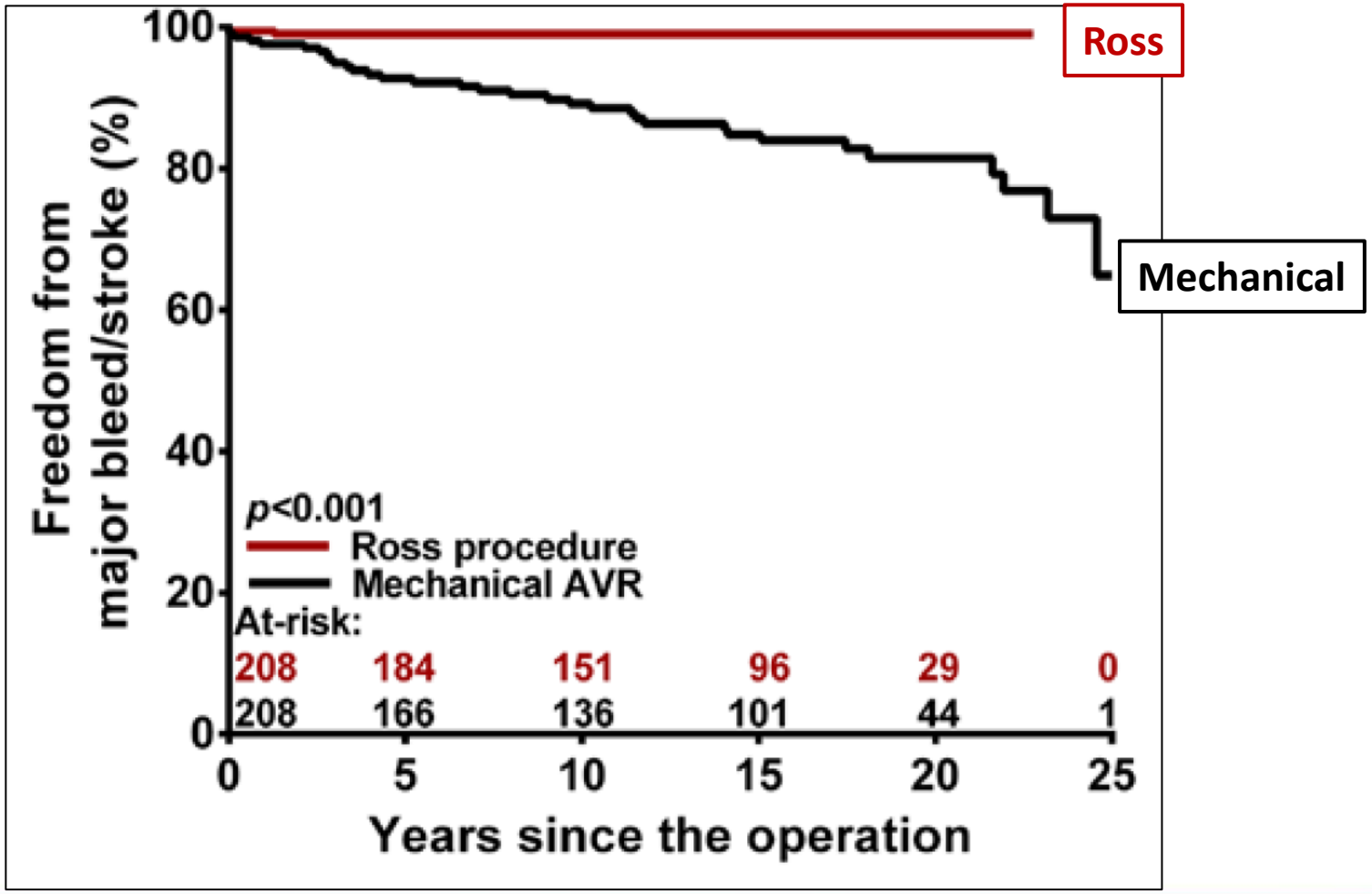
Valve-Related Complications

Valve-related complications



El-Hamamsy et al. Lancet 2010

Stroke or Bleeding



Mazine et al. Circulation 2016

Quality of Life

QUALITY OF LIFE

Quality of Life in Aortic Valve Replacement: Pulmonary Autografts Versus Mechanical Prostheses

Axel
Tho
Lübe

Long-term outcomes after autograft versus homograft aortic root replacement in adults with aortic valve disease: a randomised controlled trial

Ism
Ma

Quality of life after aortic valve surgery: Replacement versus reconstruction

Diana Aicher, MD,[a]
Hans-Joachim Schäf

Quality of life after aortic valve repair is similar to Ross patients and superior to mechanical valve replacement: a cross-sectional study

Pavel Zacek[1*†], T. Holubec[2†], M. Vobornik[1], J. Dominik[1], J. Takkenberg[3], J. Harrer[1] and J. Vojacek[1]

Notzold et al. JACC 2001
El-Hamamsy et al. Lancet 2010
Aicher et al. JTCVS 2011
Zacek et al. BMC Cardiovasc Dis 2016

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

AFFILIÉ À Université de Montréal

ACHILLE'S HEEL?

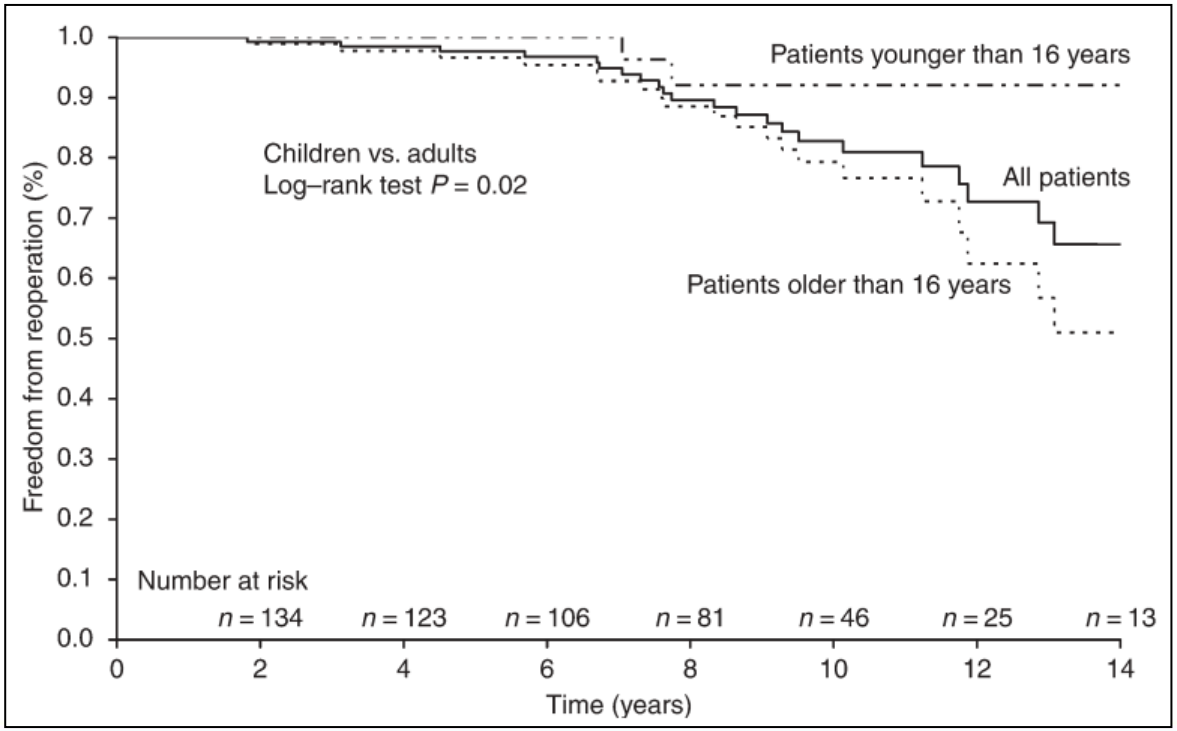
Reoperation

Reproducibility

Autograft Reoperation

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]



Klieverik et al. Eur Heart J 2007

Autograft Reoperation

Excessive pulmonary autograft dilatation causes important aortic regurgitation

R B Hokken, J J M Takkenberg, L A van Herwerden, J R T C Roelandt, A J J C Bogers

Heart 2003;**89**:933–934

There was a significant increase of the PAG annulus and sinus diameters during follow up, 22% and 27%, respectively (table 1). Most of the diameter increase was already reached at hospital discharge, with diminished increase thereafter. The

Autograft Reoperation

TECHNIQUE MATTERS

Ross Technique

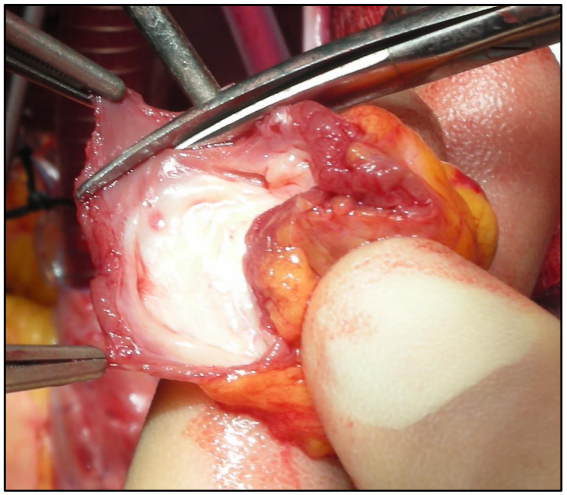
MULTIMEDIA MANUAL OF CARDIO-THORACIC SURGERY

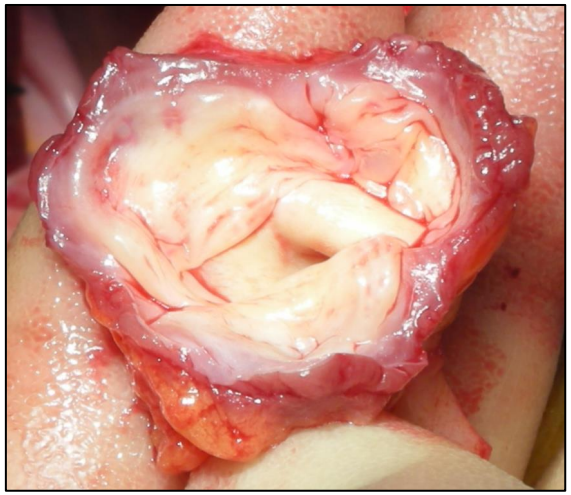
doi:10.1093/mmcts/mmu018 published online 1 October 2014.

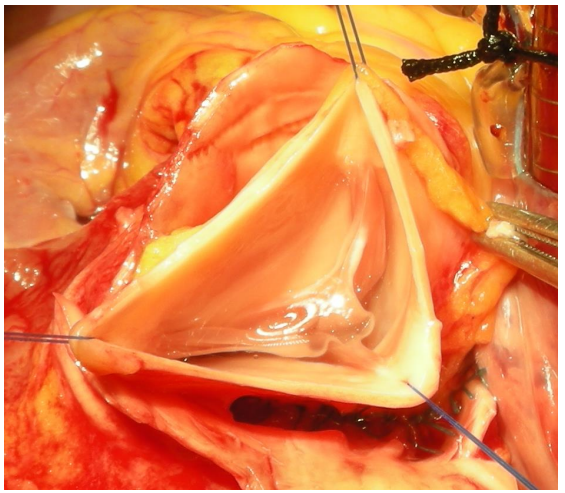
The Ross procedure: total root technique

Jessica Forcillo[a], Mustafa Cikirikcioglu[a,b], Nancy Poirier[a] and Ismail El-Hamamsy[a,*]

[a]Department of Cardiac Surgery, Montreal Heart Institute, Université de Montréal, Quebec, Canada
[b]Division of Cardiovascular Surgery, Department of Surgery, University Hospitals and Medical Faculty of Geneva, Geneva, Switzerland







Forcillo et al. MMCTS 2014

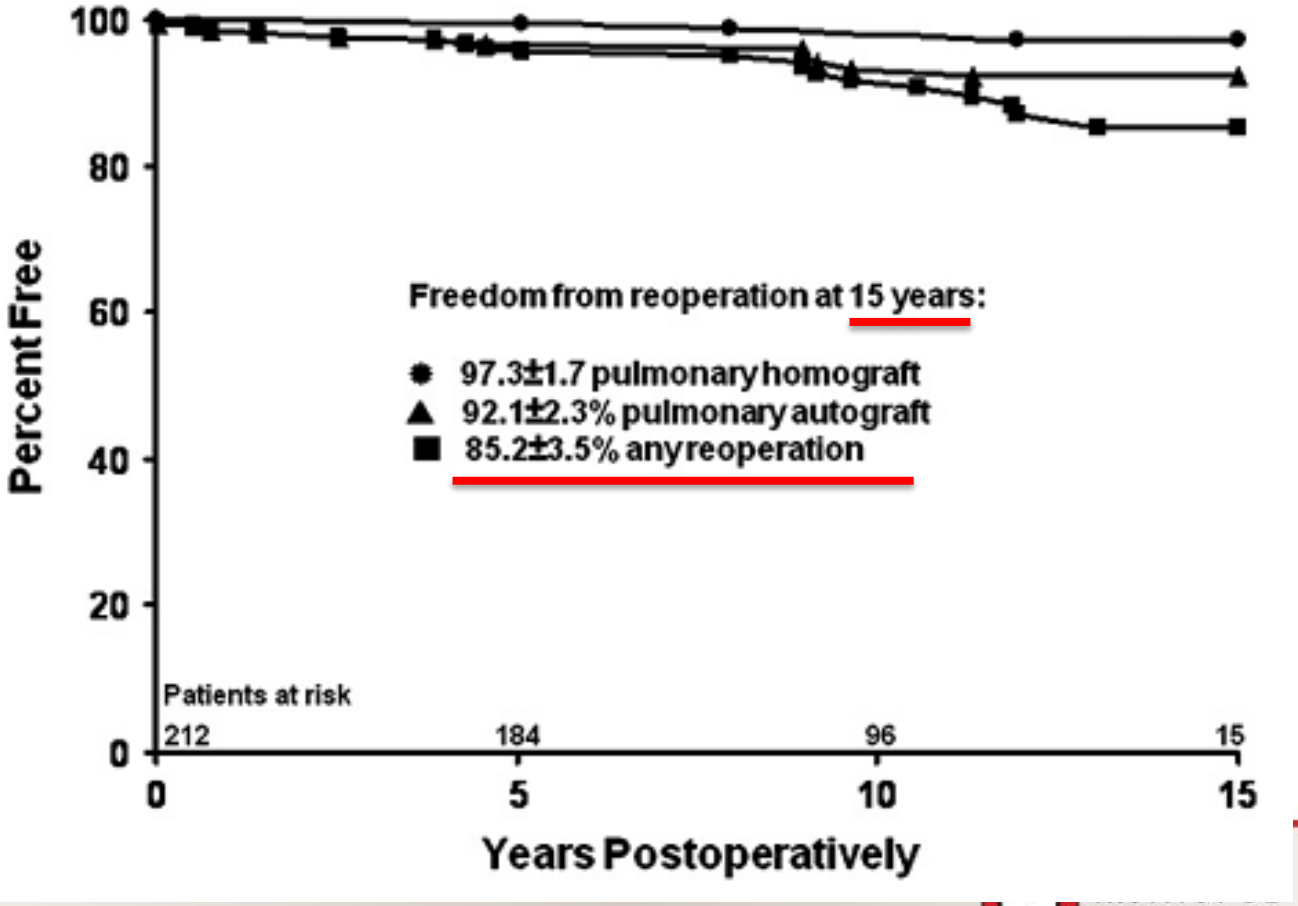
INSTITUT DE CARDIOLOGIE DE MONTRÉAL

Affiliée à Université de Montréal

Ross Reoperation (aortic/pulmonary)

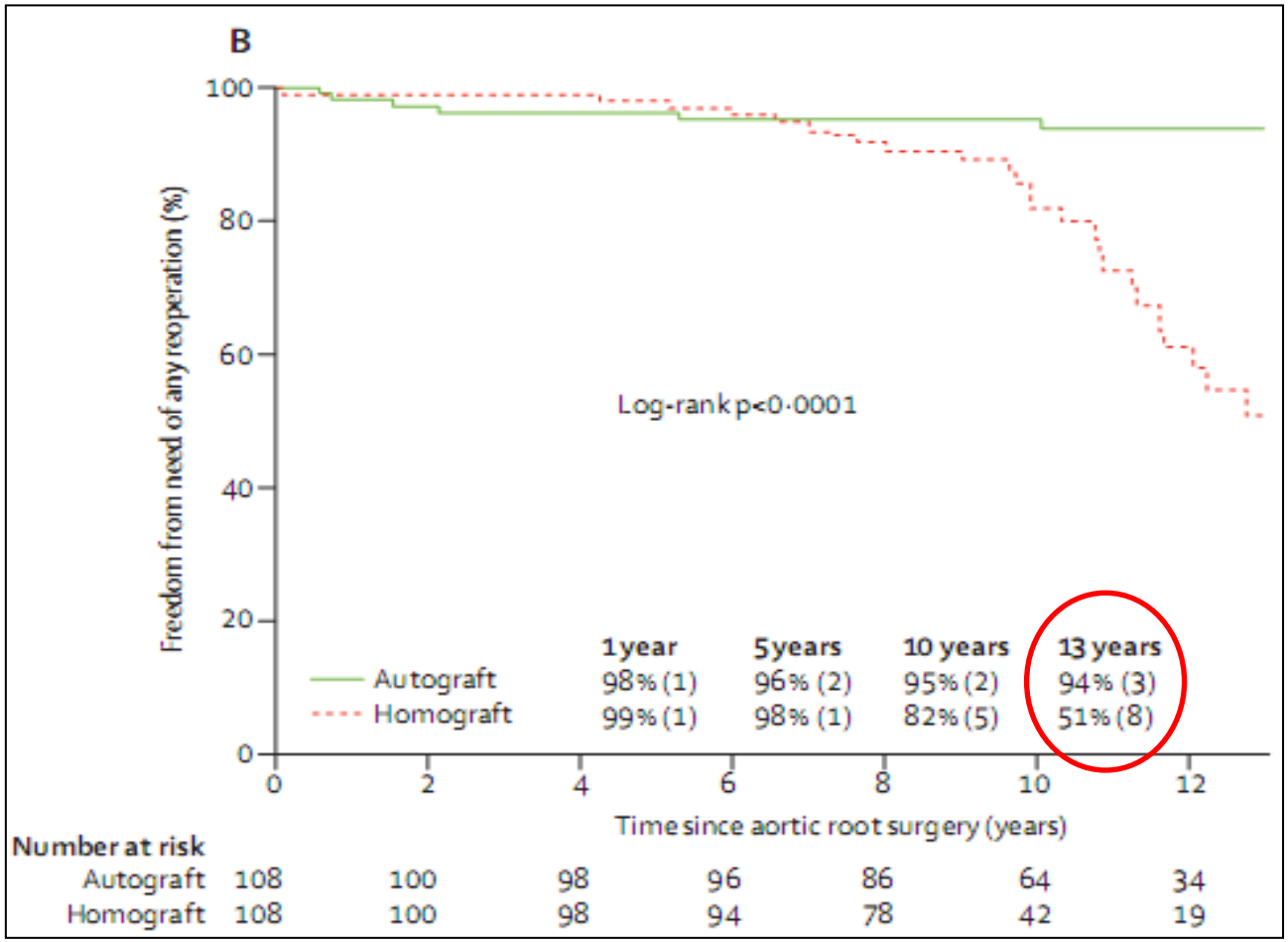
When is the Ross operation a good option to treat aortic valve disease?

Tirone E. David, MD, Anna Woo, MD, Susan Armstrong, MSc, and Manjula Maganti, MSc



David et al. JTCVS 2010

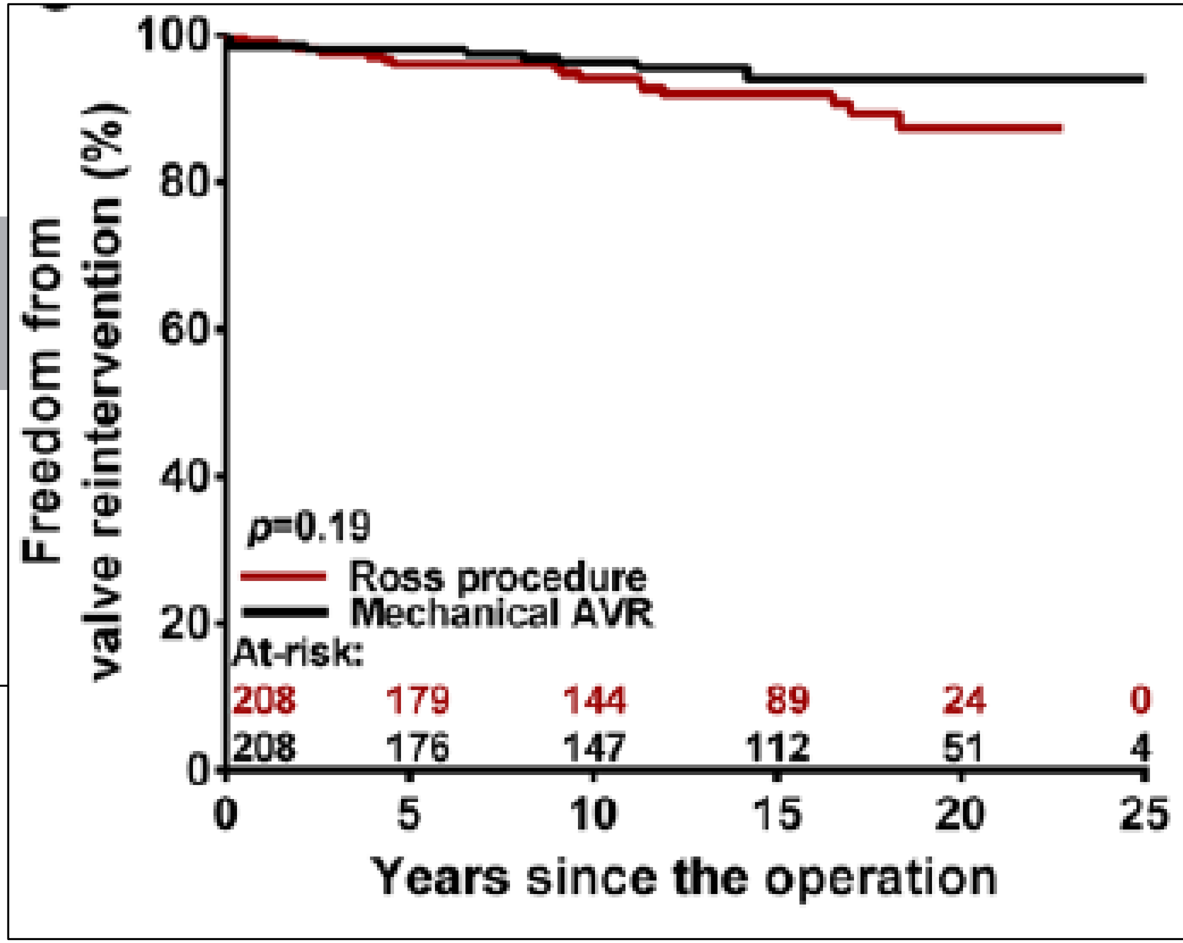
ANY Reoperation



El-Hamamsy et al. Lancet 2010

Ross Reoperation (aortic/pulmonary)

End Point	nt	*P* Value
Operated valve reintervention*		0.18



Mazine et al. Circulation 2016

INSTITUT DE CARDIOLOGIE DE MONTRÉAL
AFFILIÉ À Université de Montréal

Ross Reoperation

A multicentre evaluation of the autograft procedure for young patients undergoing aortic valve replacement: update on the German Ross Registry†

Hans-Hinrich Sievers[a,*], Ulrich Stierle[a], Efstratios I. Charitos[a], Johanna J.M. Takkenberg[b], Jürgen Hörer[c], Rüdiger Lange[c], Ulrich Franke[d], Marc Albert[d], Armin Gorski[e], Rainer G. Leyh[e], Arlindo Riso[f], Jörg Sachweh[f], Anton Moritz[g], Roland Hetzer[h] and Wolfgang Hemmer[i]

- **N= 1779 adult patients (1990-2013)**
- **8 centers**
- **Mean follow-up 8.3 years**

CONCLUSION: The autograft principle results in postoperative long-term survival comparable with that of the age- and gender-matched general population and reoperation rates within the 1%/patient-year boundaries and should be considered in young, active patients who want to avoid the shortcomings of conventional prostheses.

Sievers et al. EJCTS 2015

Ross Procedure in AI

TABLE 2. Freedom from reoperation on the pulmonary autograft

	5 y	10 y	15 y	*P* value
Operative technique				
Subcoronary/inclusion	96.3 ± 1.8 (98)	92.1 ± 3.3 (34)	92.1 ± 3.3 (10)	
Root replacement	96.9 ± 1.7 (86)	94.1 ± 2.5 (62)	92.4 ± 3.0 (4)	.82
Aortic/pulmonary annulus				
No mismatch	98.2 ± 1.2 (98)	98.2 ± 1.2 (44)	98.2 ± 1.2 (6)	
Mismatch	94.6 ± 2.3 (85)	88.5 ± 3.6 (52)	86.5 ± 4.0 (8)	.01
Aortic annulus diameter				
<27 mm	100 (80)	100 (43)	100 (3)	
≥27 mm	94.0 ± 2.1 (104)	88.7 ± 3.29 (53)	86.8 ± 3.7 (11)	.003
Aortic valve lesion				
Stenosis	99.0 ± 0.9 (93)	97.4 ± 1.9 (47)	97.4 ± 1.9 (3)	
Insufficiency	92.1 ± 3.1 (65)	87.5 ± 4.2 (34)	84.3 ± 5.2 (10)	
Mixed	100 (26)	3.7 ± 6.0 (15)	93.7 ± 6.0 (1)	.01
Sex				
Female	100 (61)	100 (35)	100 (7)	
Male	94.8 ± 1.8 (140)	90.0 ± 2.9 (61)	88.1 ± 3.4 (7)	.03

David et al. JTCVS 2010

Ross Procedure in AI

Reoperations on the pulmonary autograft and pulmonary homograft after the Ross procedure: An update on the German Dutch Ross Registry

Efstratios I. Charitos, MD,[a] Johanna J. M. Takkenberg, MD,[b] Thorsten Hanke, MD,[a] Armin Gorski, MD,[c] Cornelius Botha, MD,[d] Ulrich Franke, MD,[e] Ali Dodge-Khatami, MD,[f] Juergen Hoerer, MD,[g] Rudiger Lange, MD,[g] Anton Moritz, MD,[h] Katharina Ferrari-Kuehne, MD,[i] Roland Hetzer, MD,[j] Michael Huebler, MD,[j] Ad J. J. C. Bogers, MD,[b] Ulrich Stierle, MD,[a] Hans-Hinrich Sievers, MD,[a] and Wolfgang Hemmer, MD[k]

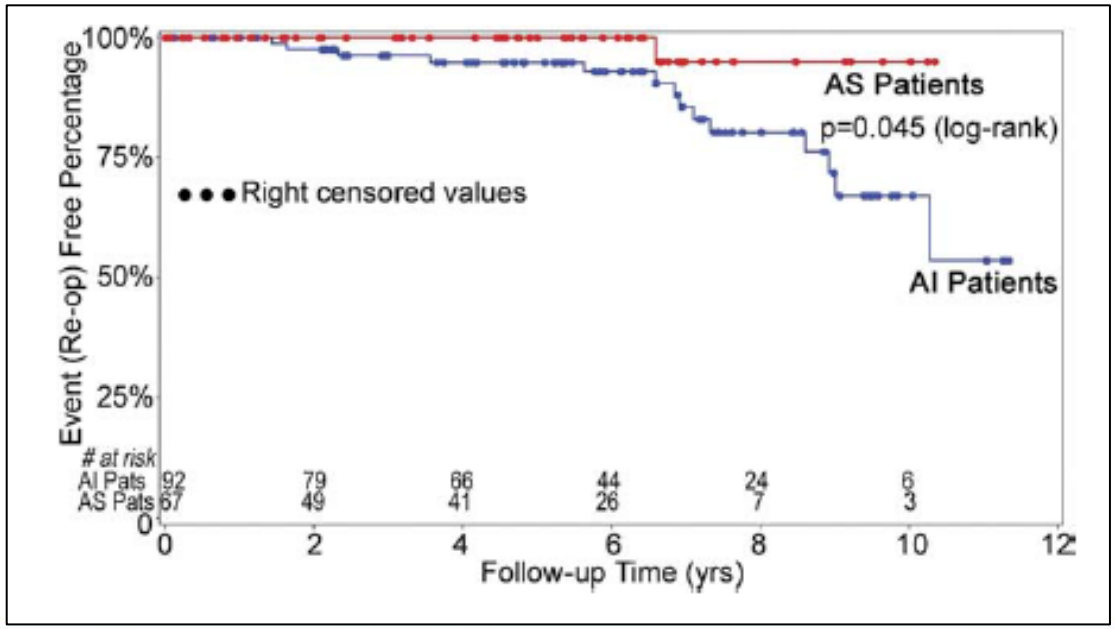
Variable	HR	95% CI	*P* value
Autograft			
Technique			
SC	Baseline		
RR+R	1.4	0.8-2.3	.25
RR	2.4	1.4-4.1	.001
Center volume	0.998/patient	0.997-0.999	.001
Preoperative hemodynamics			
Pure aortic regurgitation	2.3	1.5-3.5	<.001

Charitos et al. JTCVS 2012

Ross Procedure in AI

The Ross Procedure Performed for Aortic Insufficiency Is Associated With Increased Autograft Reoperation

William H. Ryan, MD, Syma L. Prince, RN, BSN, Dan Culica, MD, PhD, and Morley A. Herbert, PhD



Ryan et al. An Thorac Surg 2011

ROSS PROCEDURE in AI

2013 STS GUIDELINES

Aortic Valve and Ascending Aorta Guidelines for Management and Quality Measures

Writing Committee Members: Lars G. Svensson, MD, PhD (Chair), David H. Adams, MD (Vice-Chair), Robert O. Bonow, MD (Vice-Chair), Nicholas T. Kouchoukos, MD (Vice-Chair), D. Craig Miller, MD (Vice-Chair), Patrick T. O'Gara, MD (Vice-Chair), David M. Shahian, MD (Vice-Chair), Hartzell V. Schaff, MD (Vice-Chair), Cary W. Akins, MD, Joseph E. Bavaria, MD, Eugene H. Blackstone, MD, Tirone E. David, MD, Nimesh D. Desai, MD, PhD, Todd M. Dewey, MD, Richard S. D'Agostino, MD, Thomas G. Gleason, MD, Katherine B. Harrington, MD, Susheel Kodali, MD, Samir Kapadia, MD, Martin B. Leon, MD, Brian Lima, MD, Bruce W. Lytle, MD, Michael J. Mack, MD, Michael Reardon, MD, T. Brett Reece, MD, G. Russell Reiss, MD, Eric E. Roselli, MD, Craig R. Smith, MD, Vinod H. Thourani, MD, E. Murat Tuzcu, MD, John Webb, MD, and Mathew R. Williams, MD

2013 STS GUIDELINES

10. Pulmonary Autograft (Ross Procedure)—Recommendations

Class I

Class III

1. The Ross procedure is not recommended for middle-aged or older adults when suitable alternatives to autograft replacement of the aortic valve are available with comparable results and without the need for replacement of the RVOT, as the latter adds the additional risk of pulmonary valve dysfunction and subsequent replacement. (Level of evidence C)
2. The Ross procedure is not recommended for patients with bicuspid valves and AR or aortic dilation if other alternatives are available. (Level of evidence C)

patients with bicuspid valves and AR or aortic dilation if other alternatives are available. (Level of evidence C)

2013 STS GUIDELINES

218. Kouchoukos NT, Masetti P, Nickerson NJ, Castner CF, Shannon WD, Davila-Roman VG. The Ross procedure: long-term clinical and echocardiographic follow-up. Ann Thorac Surg 2004;78:773–81.
219. Yacoub MH, Klieverik LM, Melina G, et al. An evaluation of the Ross operation in adults. J Heart Valve Dis 2006;15: 531–9.
220. Klieverik LM, Takkenberg JJ, Bekkers JA, Roos-Hesselink JW, Witsenburg M, Bogers AJ. The Ross operation: a Trojan horse? Eur Heart J 2007;28:1993–2000.
221. Elkins RC, Thompson DM, Lane MM, Elkins CC, Peyton MD. Ross operation: 16-year experience. J Thorac Cardiovasc Surg 2008;136:623–30. e1-5.
222. de Kerchove L, Rubay J, Pasquet A, et al. Ross operation in the adult: long-term outcomes after root replacement and inclusion techniques. Ann Thorac Surg 2009;87:95–102.
223. Bohm JO, Hemmer W, Rein JG, et al. A single-institution experience with the Ross operation over 11 years. Ann Thorac Surg 2009;87:514–20.
224. David TE, Woo A, Armstrong S, Maganti M. When is the Ross operation a good option to treat aortic valve disease? J Thorac Cardiovasc Surg 2010;139:68–75.
225. Karamlou T, Jang K, Williams WG, et al. Outcomes and associated risk factors for aortic valve replacement in 160 children: a competing-risks analysis. Circulation 2005;112: 3462–9.
226. Alsoufi B, Al-Halees Z, Manlhiot C, et al. Mechanical valves versus the Ross procedure for aortic valve replacement in children: propensity-adjusted comparison of long-term outcomes. J Thorac Cardiovasc Surg 2009;137:362–70. e9.

Freedom from Reoperation

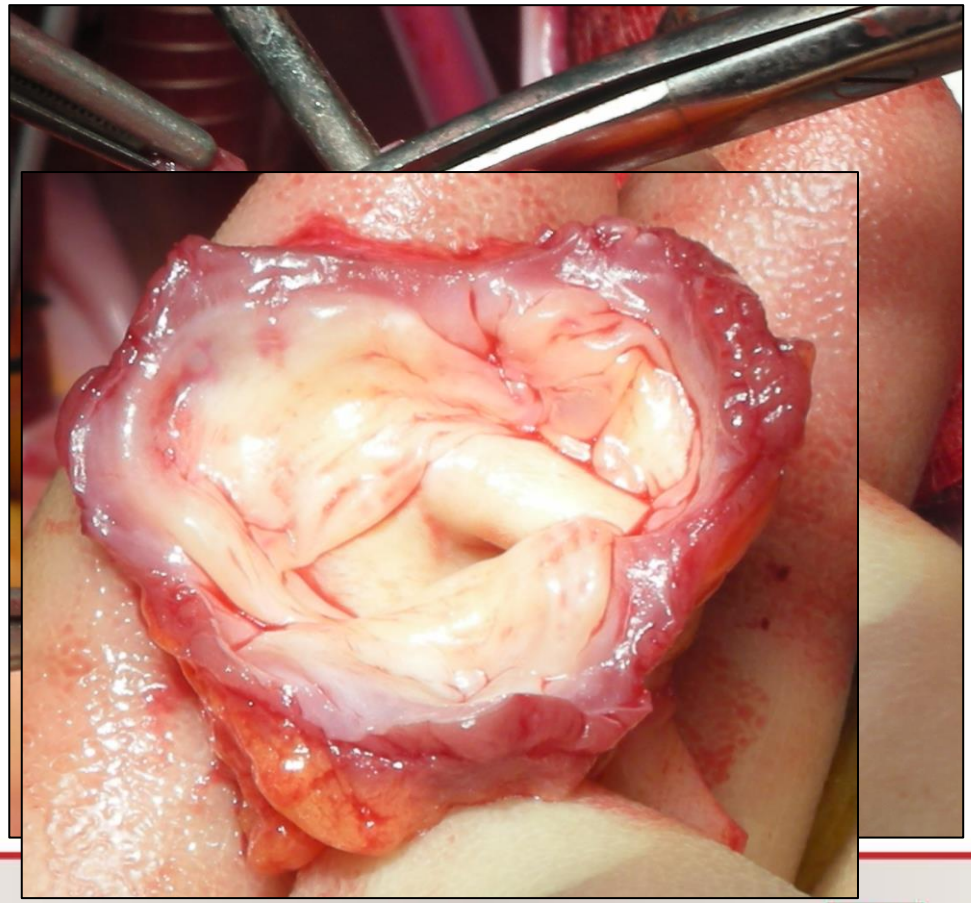
Study	Study Type	Study Period	N	Mean Follow-up (years)	Mean Age (years)	BAV (%)	AS (%) / AI (%) / Mixed AS-AI (%)	Operative mortality (%)	5-Year Freedom from reoperation (%)	10-Year Freedom from reoperation (%)	15-Year Freedom from reoperation (%)
El-Hamamsy et al. (2010)	RCT	1994-2001	216 pts (108 Ross)	10.2 (2173 pt-yrs)	38	49%	28% 45% 27%	0.9%	96%	95%	94%
Sievers et al. (2015)	Multicenter Ross Registry (prospective)	1990-2013	1779	8.3 (14,288 pt-yrs)	44.7	64.8%	24% 22% 52%	1.1%	94.9%	91.1%	82.7%
David et al. (2014)	Single center	1990-2004	212	13.8*	34	71.7%	50% 36%	0.4%	AG 98% HG 100%	AG 97% HG 98%	AG 93% HG 96%
Mastrobuoni et al. (2015)											75% (AS 83%) (AI 65%)
Skillington et al. (2013)											93%
Da Costa et al. (2014)	Single center	1995-2013	414	8,2	30.8	50%	29% 39% 31%	2.7%	NA	NA	81%
Kalfa et al. (2015)	Single center	1990-2013	221	11.4*	41.5	76.5%	81% 0% 19%	0.9%	NA	95%	88%
Andreas et al. (2014)	Single center	1991-2011	246	10*	29	75%	29% 40% 31%	1.6%	95%	88%	81%

ISOLATED AORTIC INSUFFICIENCY: 22-45%

MIXED AS/AI: 19-52%

Tailored Ross Technique

- Trimming of infudibular muscle below the valve
- Scalloping

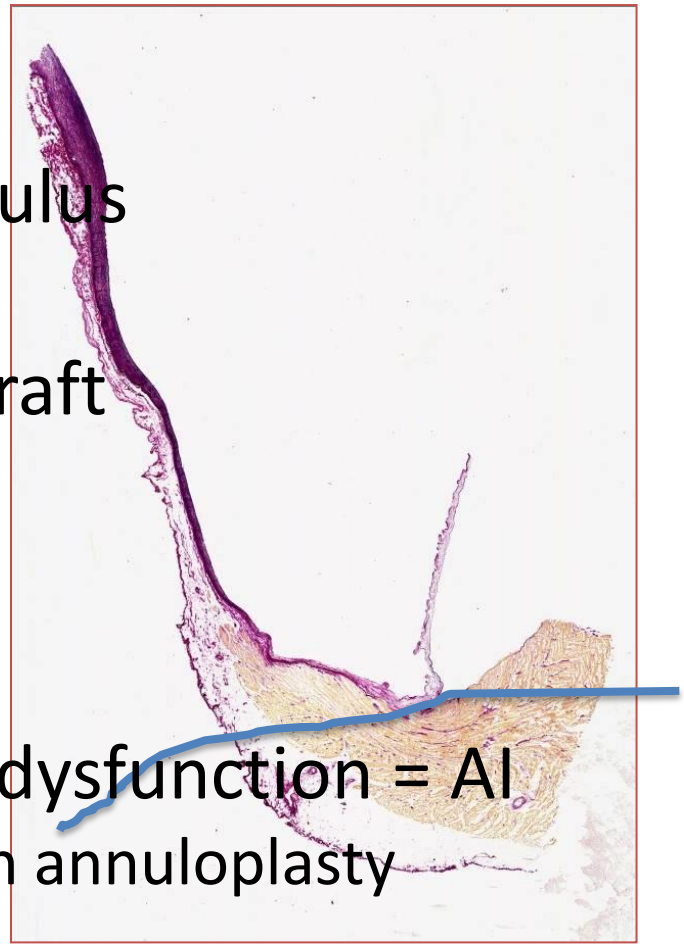


Forcillo et al. MMCTS 2014

Tailored Ross Technique

Proximal suture line

- Sub-annular sutures in aortic annulus
- Tangential sutures through autograft
- Single interrupted sutures
- Extra-aortic annuloplasty if valve dysfunction = AI
  - If size mismatch >2mm → reduction annuloplasty
  - If no mismatch → aim to stabilize

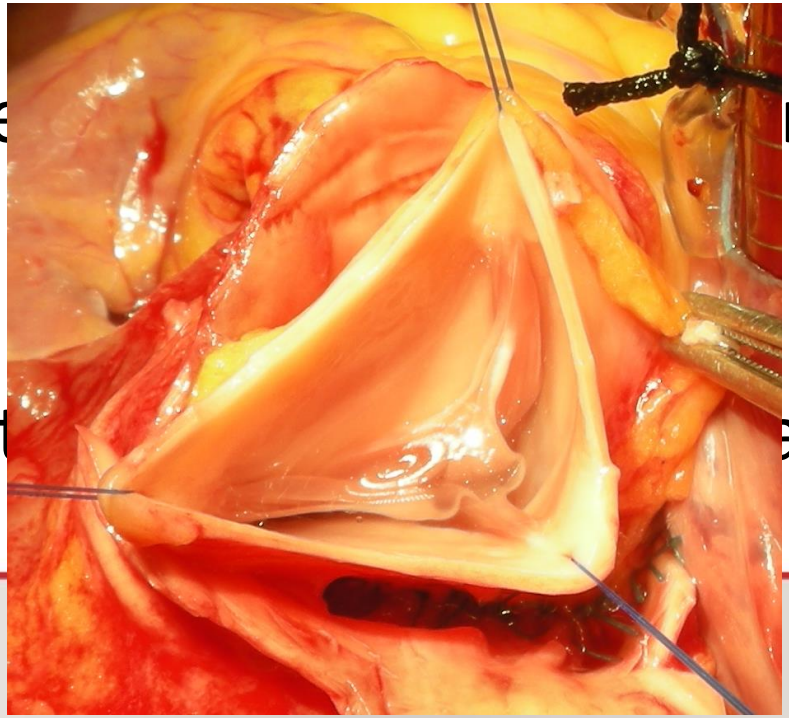


Forcillo et al. MMCTS 2014

Tailored Ross Technique

Distal Suture Line

- Short autograft above STJ (or coronary anastomosis) (max 2-3mm)
- Short inte nding aorta >40mm
- Careful at al symmetry



Forcillo et al. MMCTS 2014

Reproducible?

MONTREAL HEART INSTITUTE (N=275)

2011-2017

275 patients: Mean age 42 yrs (16-67 yrs)

- 13% redos (N=36)
- 60% concomittant procedures
- 6% active endocarditis (N=16)

Operative mortality: 0.7% (n=2)

Ross vs. Conventional AVR

Is the Ross procedure a riskier operation? Perioperative outcome comparison with mechanical aortic valve replacement in a propensity-matched cohort†

Ismail Bouhout[a,†], Pierre-Emmanuel Noly[a,†], Aly Ghoneim[a], Louis-Mathieu Stevens[b], Raymond Cartier[a], Nancy Poirier[a], Denis Bouchard[a], Philippe Demers[a] and Ismail El-Hamamsy[a,*]

OBJECTIVES: The aim of this study was to compare perioperative outcomes in young adults following isolated Ross procedure versus mechanical aortic valve replacement (AVR) in a high-volume centre.

METHODS: From 2007 to 2015, 337 elective isolated mechanical AVRs and 137 Ross procedures were performed in young adults (<65 years) at our centre. Using a 1:1 propensity score match analysis, 140 patients were included in the study ($n = 70$ in each group). Perioperative outcomes were defined using STS guidelines. The primary outcome was operative mortality.

RESULTS: Median age was 52 [14] years and EuroSCORE II was 1.0 [0.4]%. There were no mortalities in the two groups. There were no differences in the incidence of myocardial injury (0% overall) and neurological complications (0.7% overall). Three (4%) reinterventions for bleeding were required in the Ross cohort versus six (9%) in the mechanical AVR cohort ($P = 0.49$). A significant increase in serum creatinine (>2-fold increase) was more commonly observed after the Ross procedure (11 vs 1%; $P = 0.03$), but there was no significant difference in the rate of temporary dialysis. Twenty-seven patients (39%) required ≥1 blood product transfusion in the Ross group, whereas 21 patients (31%) did so in the mechanical AVR group ($P = 0.47$). Median hospital length of stay was similar in both the groups (6 days).

CONCLUSIONS: There are no differences in mortality or major perioperative outcomes in adults undergoing an isolated Ross procedure or mechanical AVR.

Bouhout et al. ICVTS 2016

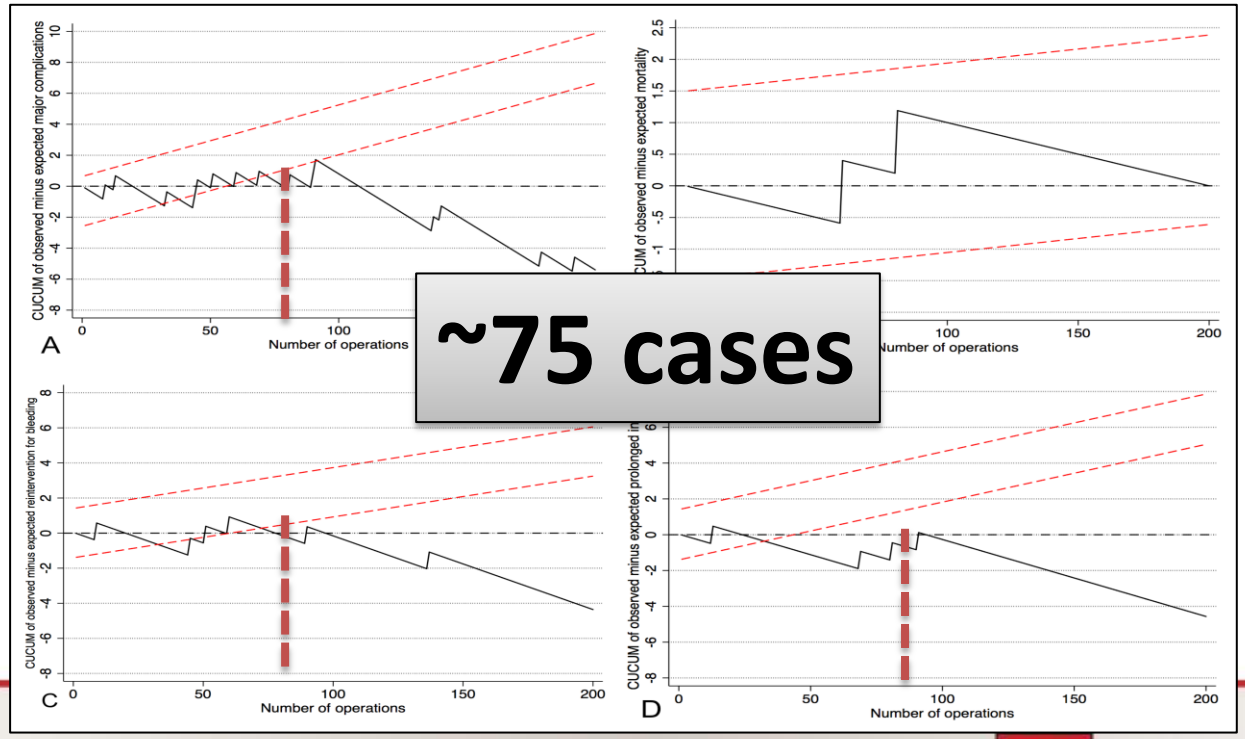
Ross Learning Curve

Canadian Journal of Cardiology ■ (2016) 1–8

Clinical Research

Impact of the Learning Curve on Early Outcomes Following the Ross Procedure

Ismail Bouhout, MD, Aly Ghoneim, MD, Nancy Poirier, MD, Raymond Cartier, MD, Philippe Demers, MD, Louis P. Perrault, MD, PhD, and Ismail El-Hamamsy, MD PhD



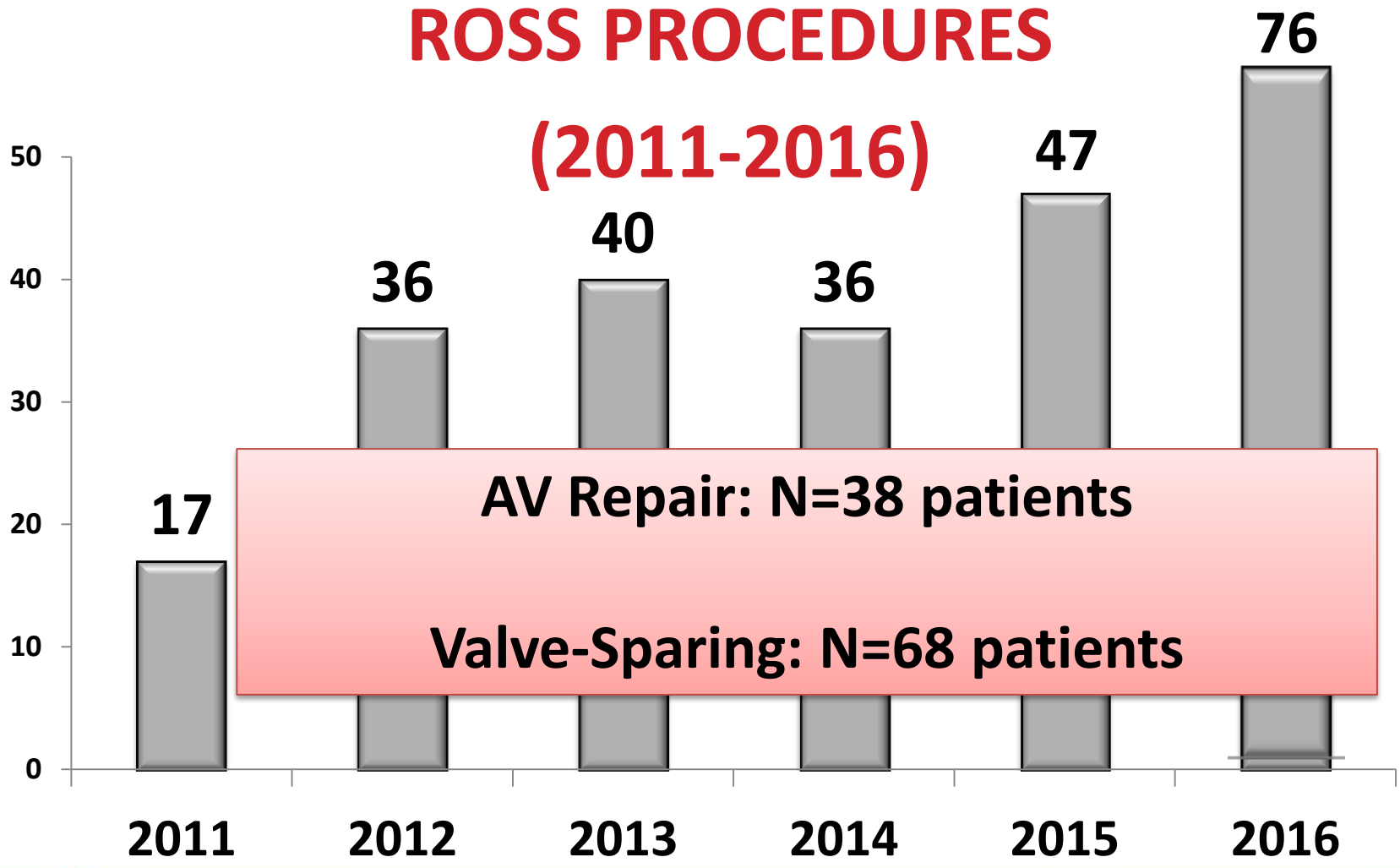
~75 cases

Bouhout et al. Can J Cardiol 2017

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

AFFILIÉ À Université de Montréal

MONTREAL HEART INSTITUTE (N=275)



INSTITUT DE CARDIOLOGIE DE MONTRÉAL

Université de Montréal

Tailored Approach (N=275)

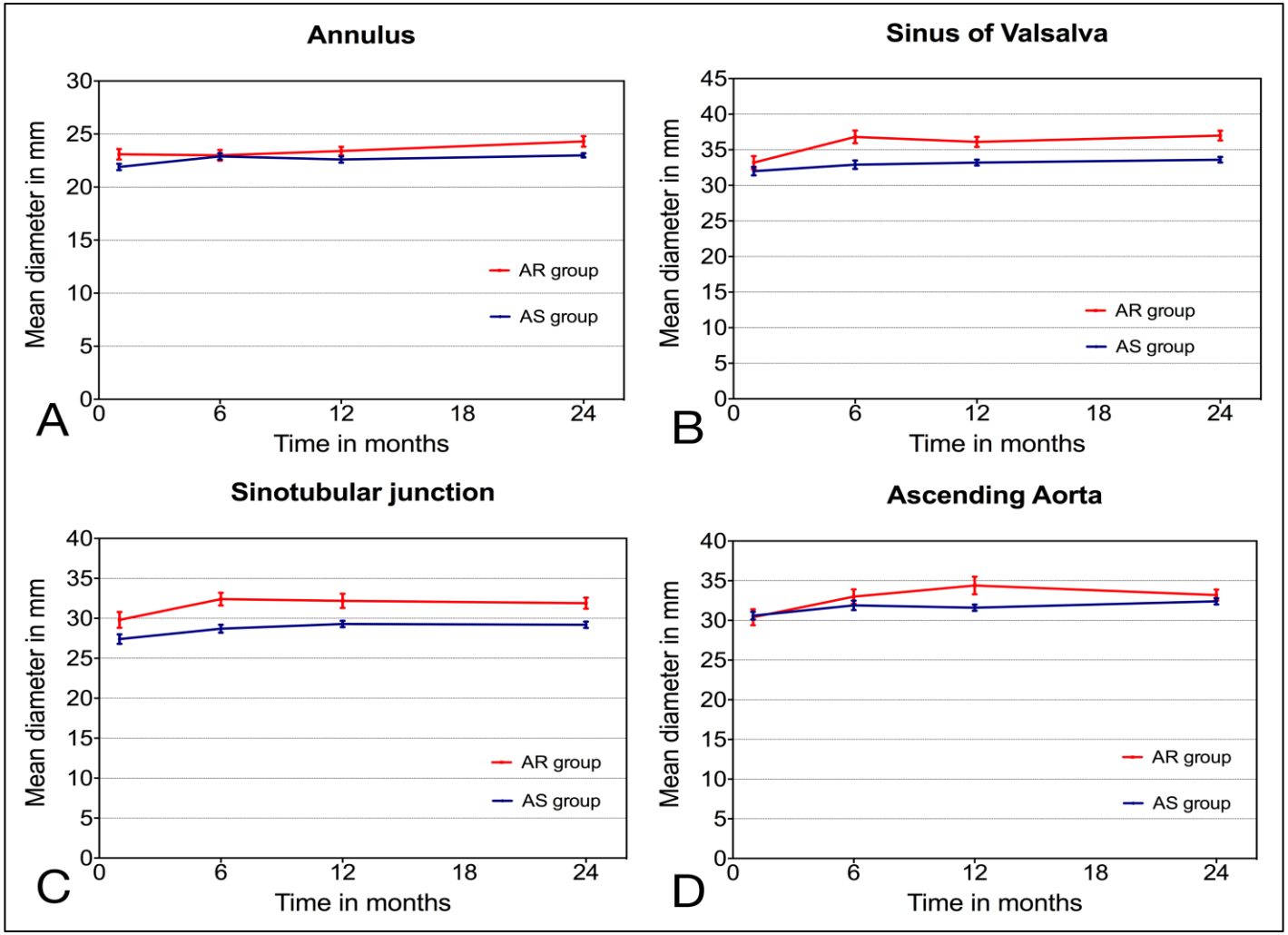
2011-2017

- Isolated AS: 201 (73%)
- **Isolated AI: 63 (23%)**
- **Mixed AS/AI: 11 (4%)**

- Bicuspid: 156 (57%)
- Unicuspid: 72 (26%)
- Tricuspid: 30 (11%)
- Quadricuspid: 3 (1%)

- **Extra-Aortic Annuloplasty: N=57 (26%)**
- **Ascending Aortic Replacement: N=141 (52%)**

Impact of a Tailored Approach

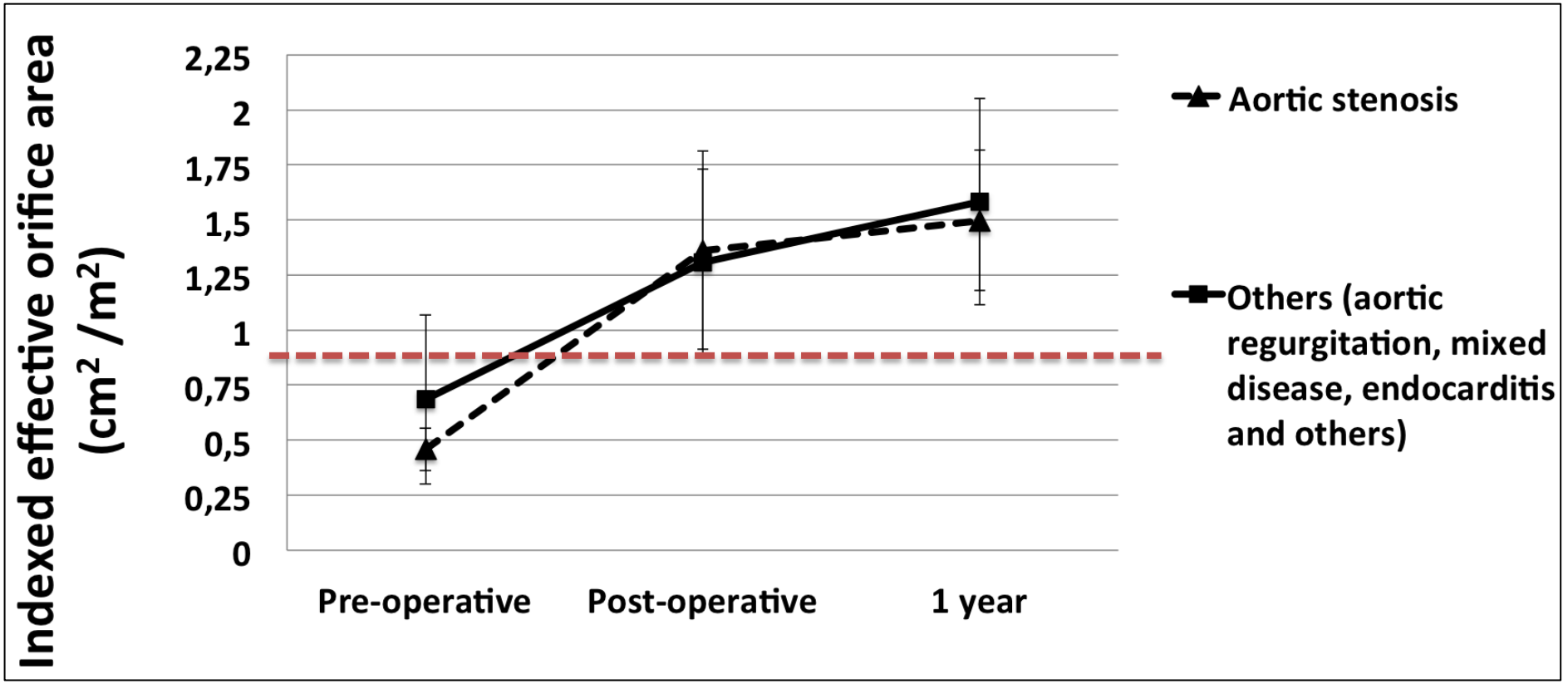


Bouhout et al., HVS 2017

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

Université de Montréal

iEOA


Indexed effective orifice area (cm² /m²)
2,25
2
1,75
1,5
1,25
1
0,75
0,5
0,25
0
Pre-operative
Post-operative
1 year
Aortic stenosis
Others (aortic regurgitation, mixed disease, endocarditis and others)

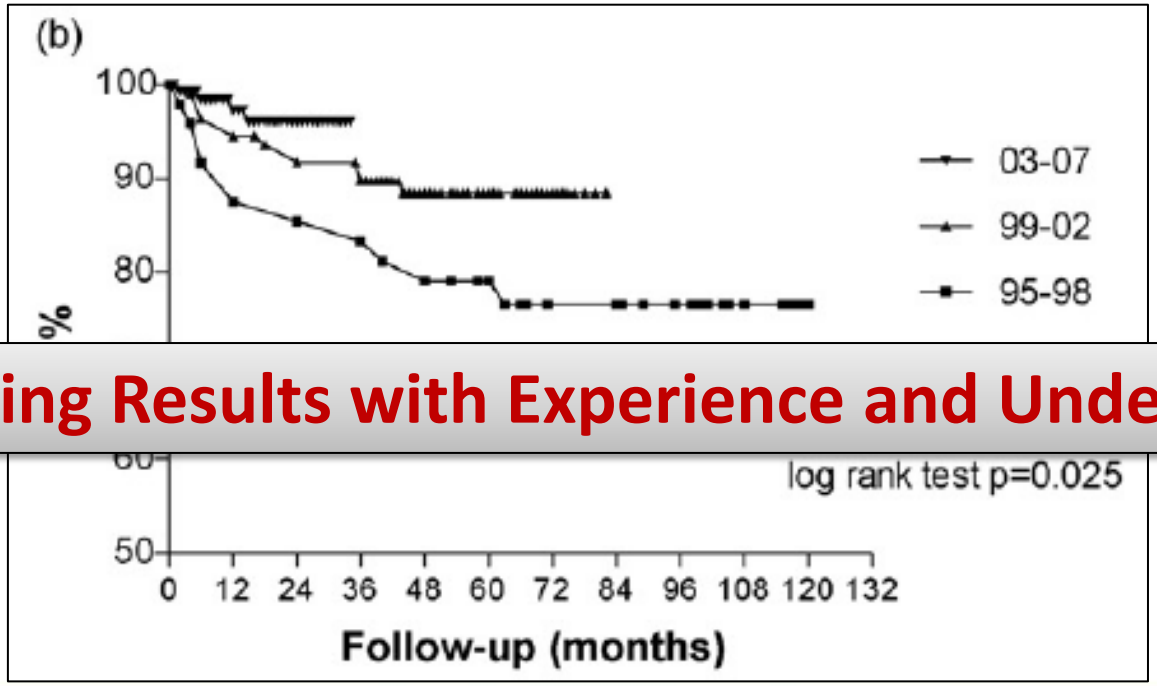
WHAT ABOUT ISOLATED AV REPAIR?

AV Repair Durability

Aortic valve repair leads to a low incidence of valve-related complications

Diana Aicher [a], Roland Fries [b], Svetlana Rodionycheva [a], Kathrin Schmidt [a], Frank Langer [a], Hans-Joachim Schäfers [a,*]

Freedom from AR ≥ II



Improving Results with Experience and Understanding

Aicher et al. EJCTS 2010

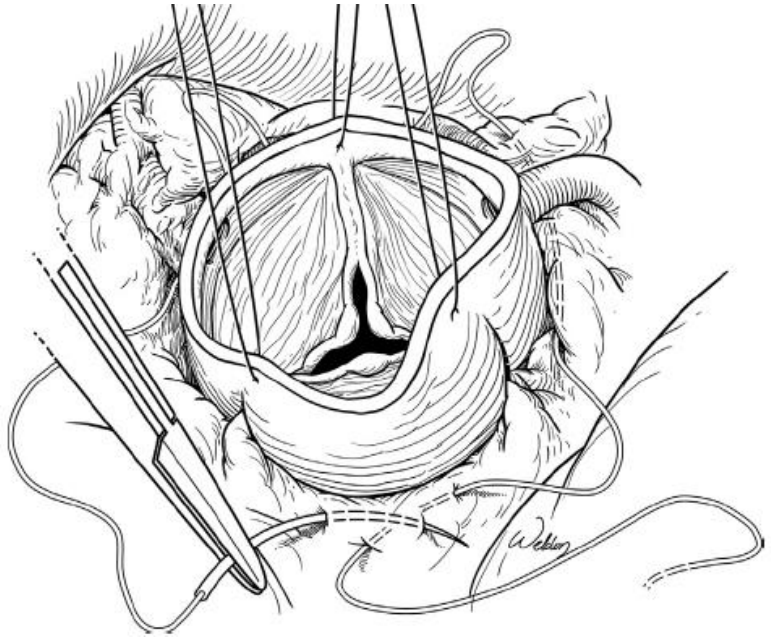
INSTITUT DE CARDIOLOGIE DE MONTRÉAL

Université de Montréal

BAV Repair Durability

Suture Annuloplasty Significantly Improves the Durability of Bicuspid Aortic Valve Repair

Ulrich Schneider, MD, Christopher Hofmann, Diana Aicher, MD,
Hiroaki Takahashi, MD, Yujiro Miura, MD, and Hans-Joachim Schäfers, MD

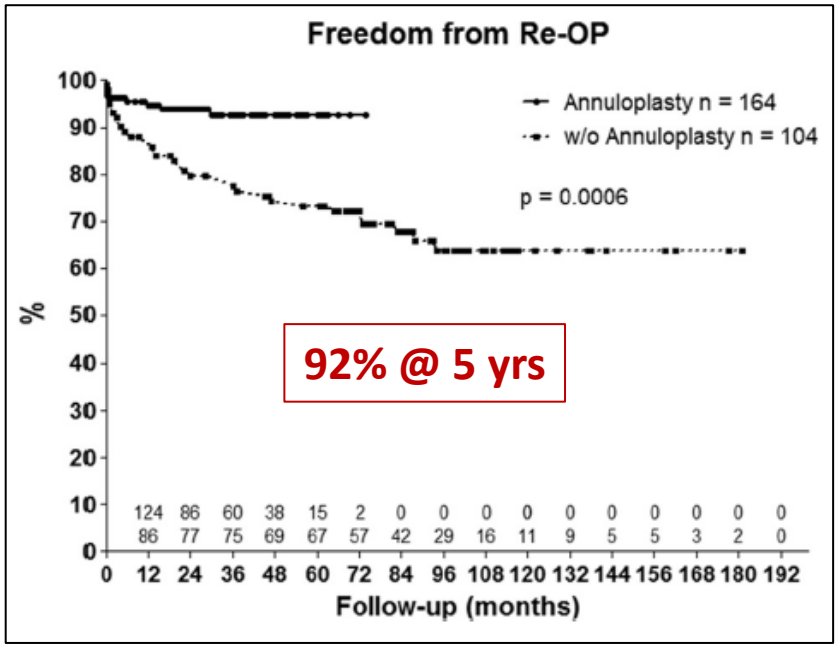


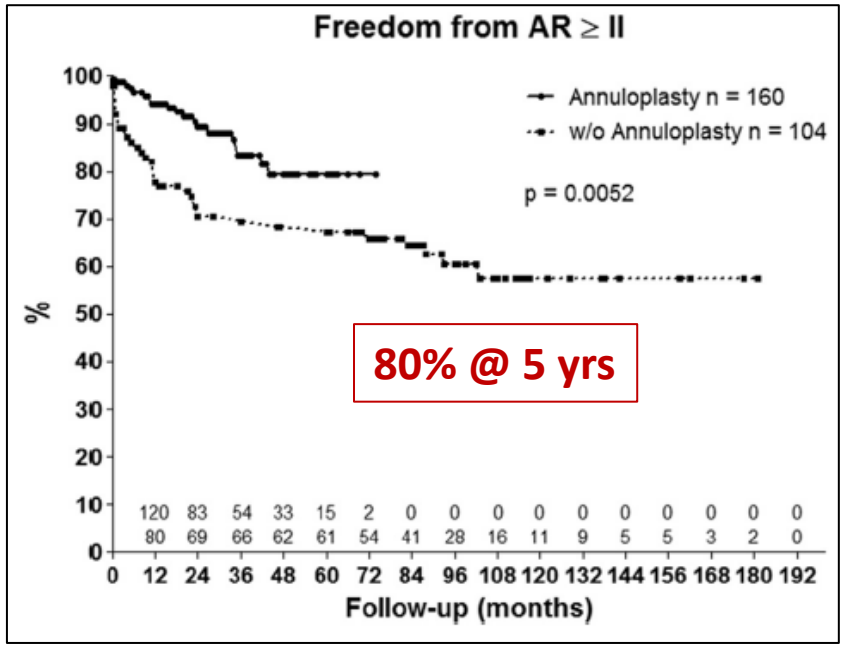
Schneider et al. Ann Thorac Surg 2017

BAV Repair Durability

Suture Annuloplasty Significantly Improves the Durability of Bicuspid Aortic Valve Repair

Ulrich Schneider, MD, Christopher Hofmann, Diana Aicher, MD,
Hiroaki Takahashi, MD, Yujiro Miura, MD, and Hans-Joachim Schäfers, MD





Schneider et al. Ann Thorac Surg 2017

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

AFFILIÉ À Université de Montréal

AV Repair Durability

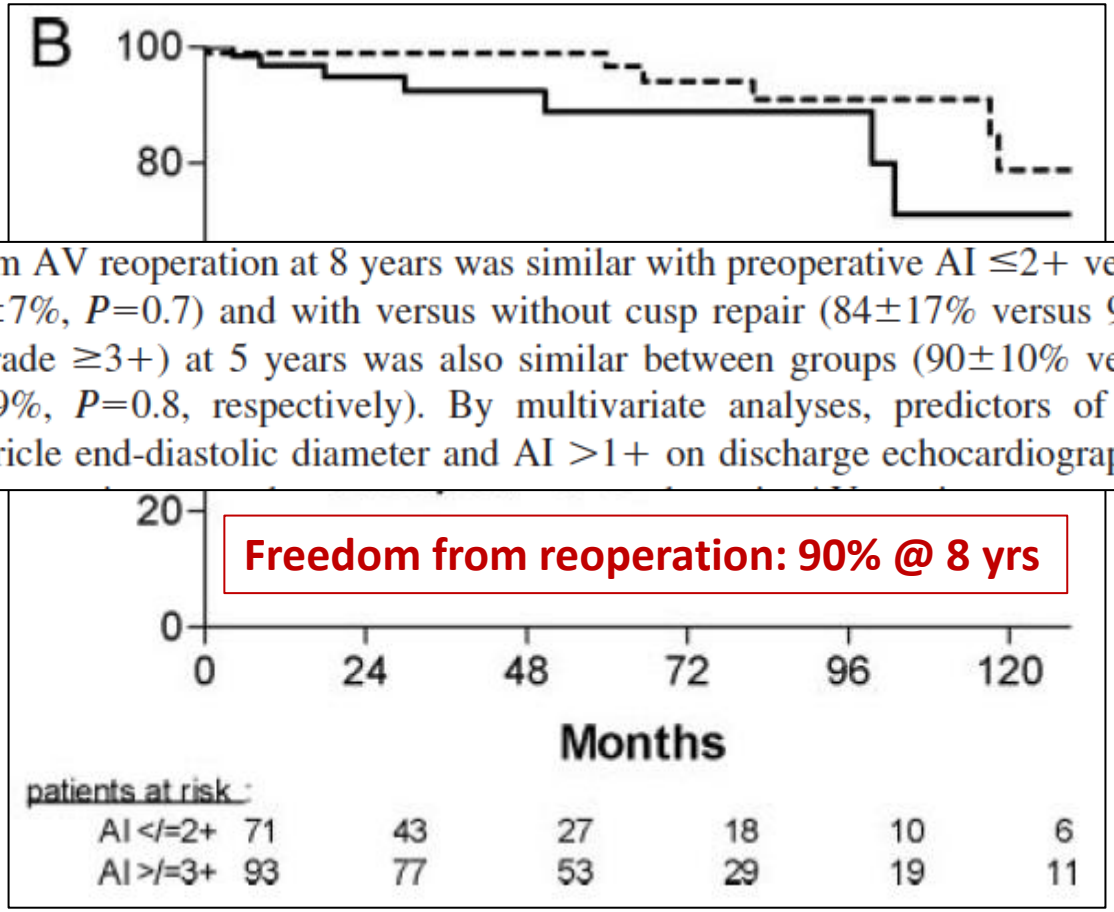
Effects of Preoperative Aortic Insufficiency on Outcome After Aortic Valve–Sparing Surgery

Laurent de Kerchove, MD; Munir Boodhwani, MD, MMSC; David Glineur, MD; Alain Poncelet, MD; Robert Verhelst, MD; Parla Astarci, MD; Valérie Lacroix, MD; Jean Rubay, MD, PhD; Michel Vandyck, MD; Jean-Louis Vanoverschelde, MD, PhD; Philippe Noirhomme, MD; Gebrine El Khoury, MD

	AI ≤2+, n=71*	AI ≥3+, n=93*	*P* Value
Age, y	50±15	52±16	0.5
Men	62 (87%)	77 (83%)	0.6
NYHA functional class			
1	48 (68%)	23 (25%)	
2	22 (31%)	52 (56%)	
3	1 (2%)	17 (18%)	<0.001
4	0	0	
Previous cardiac surgery	5 (7%)	5 (5%)	0.9
LV ejection fraction, %			
>50	70 (99%)	83 (89%)	0.06
30–50	1 (1%)	9 (10%)	
<30	0	1 (1%)	
LV end-systolic diameter, mm	34±6	41±9	<0.001
LV end-diastolic diameter, mm	54±6	61±9	<0.001
AI grade, preoperative			
0	3 (4%)	0	...
1	36 (51%)	0	
2	32 (45%)	0	
3	0	76 (82%)	
4	0	17 (18%)	
Aortic root diameter, mm	52±7	54±9	0.15
Etiology			
Degenerative	35 (49%)	56 (60%)	0.2
Bicuspid valve	24 (34%)	30 (32%)	1
Marfan syndrome	12 (17%)	6 (7%)	0.06
Endocarditis	0	1 (1%)	0.9

De Kerchove et al. Circulation 2009

AV Repair Durability



88±8%. Freedom from AV reoperation at 8 years was similar with preoperative AI ≤2+ versus preoperative AI ≥3+ (89±11% versus 90±7%, *P*=0.7) and with versus without cusp repair (84±17% versus 92±8%, *P*=0.5). Freedom from recurrent AI (grade ≥3+) at 5 years was also similar between groups (90±10% versus 89±8%, *P*=0.9, and 90±8% versus 89±9%, *P*=0.8, respectively). By multivariate analyses, predictors of recurrent AI ≥2+ were preoperative left ventricle end-diastolic diameter and AI >1+ on discharge echocardiography.

Freedom from reoperation: 90% @ 8 yrs

De Kerchove et al. Circulation 2009

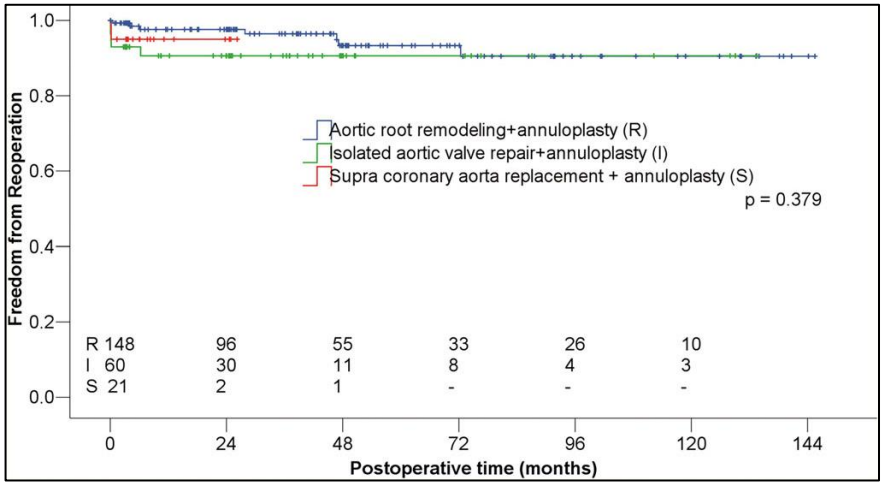
INSTITUT DE CARDIOLOGIE DE MONTRÉAL

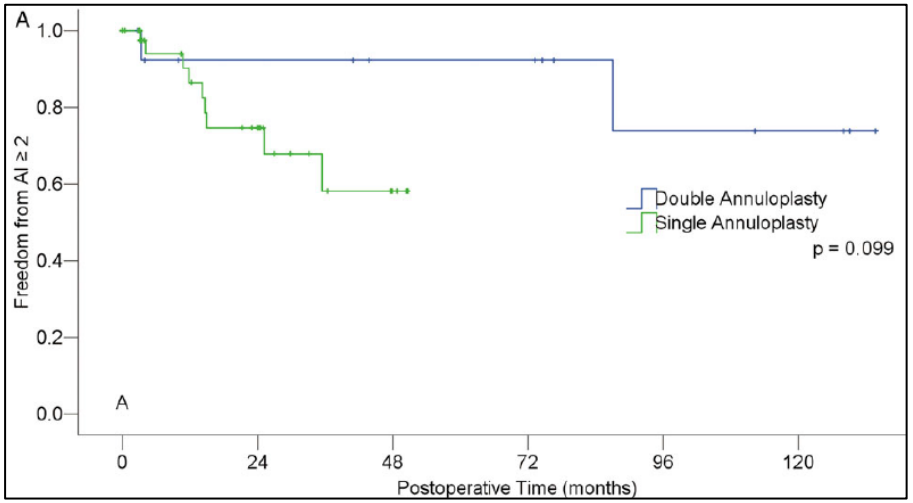
Université de Montréal

AV Repair Durability

Long-term results of external aortic ring annuloplasty for aortic valve repair†

Emmanuel Lansac[a,*], Isabelle Di Centa[b], Ghassan Sleilaty[a], Stephanie Lejeune[a], Nizar Khelil[a], Alain Berrebi[a], Christelle Diakov[a], Leila Mankoubi[a], Marie-Christine Malergue[a], Milena Noghin[a], Konstantinos Zannis[a], Suzanna Salvi[a], Patrice Dervanian[a] and Mathieu Debauchez[a]





Lansac et al. EJCTS 2016

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

AFFILIÉ À Université de Montréal

ROSS VS. REPAIR?

ROSS VERSUS REPAIR

- Non-competing, complimentary tools

- Option A (*when feasible and durable*): REPAIR

  Option B: Ross Procedure

- Despite the higher rate of reoperation after the Ross procedure in AI, outcomes remain significantly better than conventional AVR

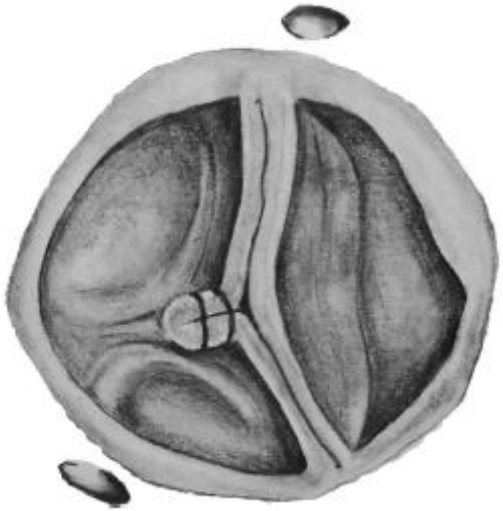
ROSS VERSUS REPAIR

- A tailored approach to the Ross is required in patients with AI

- A good Ross is better than a questionable repair

Successful Repair of a Bicuspid Pulmonary Autograft Valve Causing Early Insufficiency After a Ross Procedure

Nicola Vistarini, MD, MS, Caroline Gebhard, MD,
Georges Desjardins, MD, and
Ismail El-Hamamsy, MD, PhD



ROSS VERSUS REPAIR

Typical “grey zone” scenario

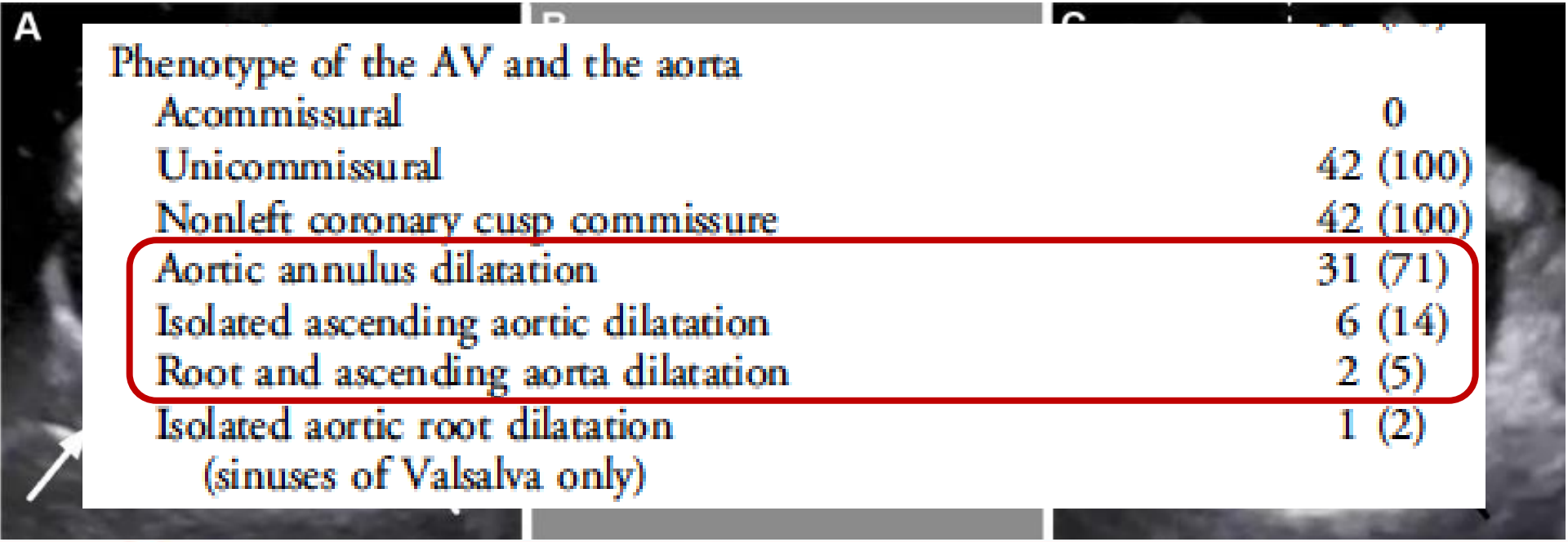
- Young patient (<30-35 yo)
- Unicuspid AV
- Dilated aortic annulus
- Potentially repairable valve

UNICUSPID AORTIC VALVES

Clinical Research

New Insights Into Unicuspid Aortic Valve Disease in Adults: Not Just a Subtype of Bicuspid Aortic Valves

Pierre-Emmanuel Noly, MD,[a] Lauren Basmadjian, MD,[a] Ismail Bouhout, MD,[a]
Van Hoai Viet Le, MD,[b] Nancy Poirier, MD,[a] and Ismail El-Hamamsy, MD, PhD[a]



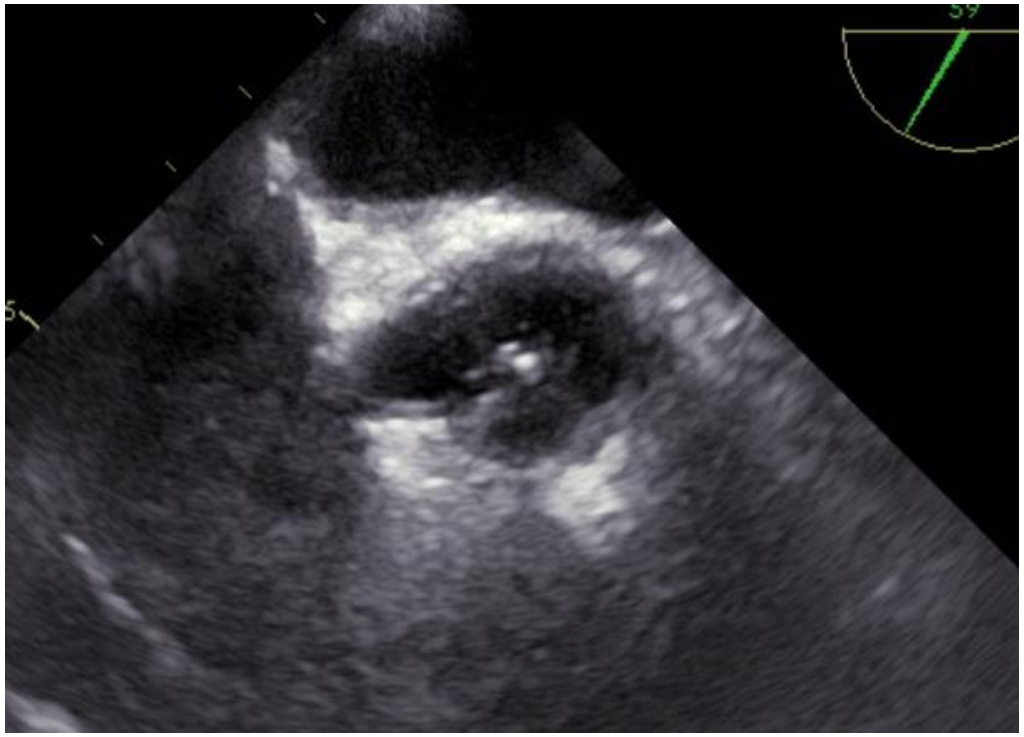
Phenotype of the AV and the aorta	
Acommissural	0
Unicommissural	42 (100)
Nonleft coronary cusp commissure	42 (100)
Aortic annulus dilatation	31 (71)
Isolated ascending aortic dilatation	6 (14)
Root and ascending aorta dilatation	2 (5)
Isolated aortic root dilatation (sinuses of Valsalva only)	1 (2)

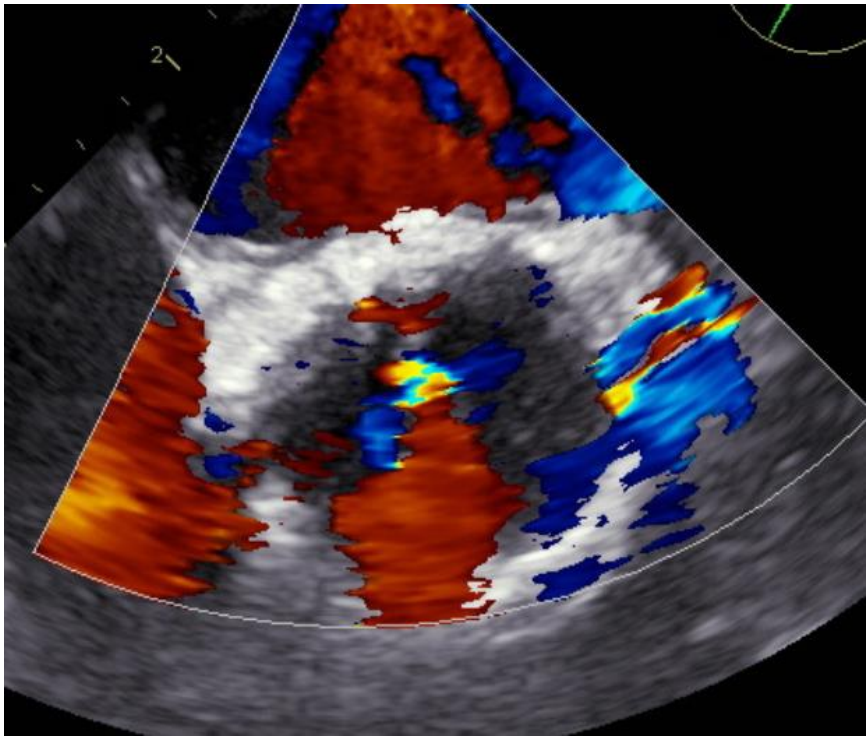
Noly et al. Can J Cardiol 2016

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

Université de Montréal

UAV REPAIR (BICUSPIDIZATION)





UAV REPAIR IN AI

2012-2015

AV Repair (Bicuspidization)
+ Annuloplasty
N=15

Repair failure
N=4

2011-2017

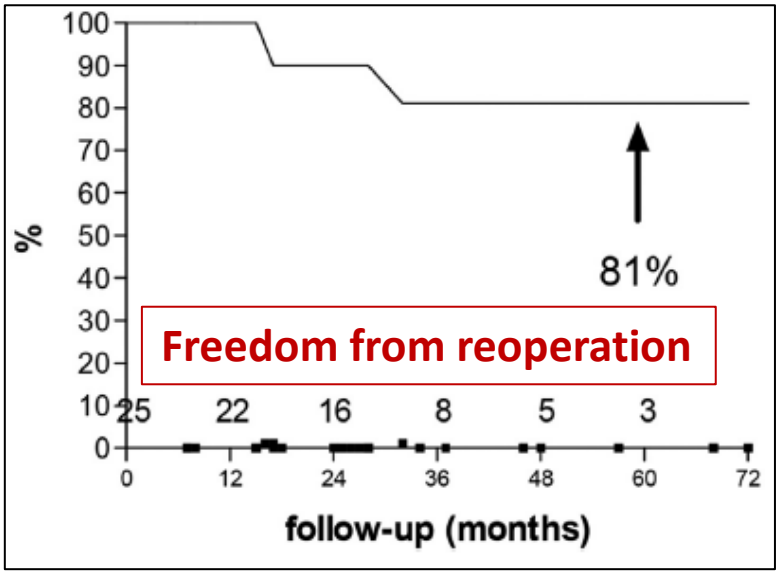
Ross Procedure
+ Annuloplasty
N=21

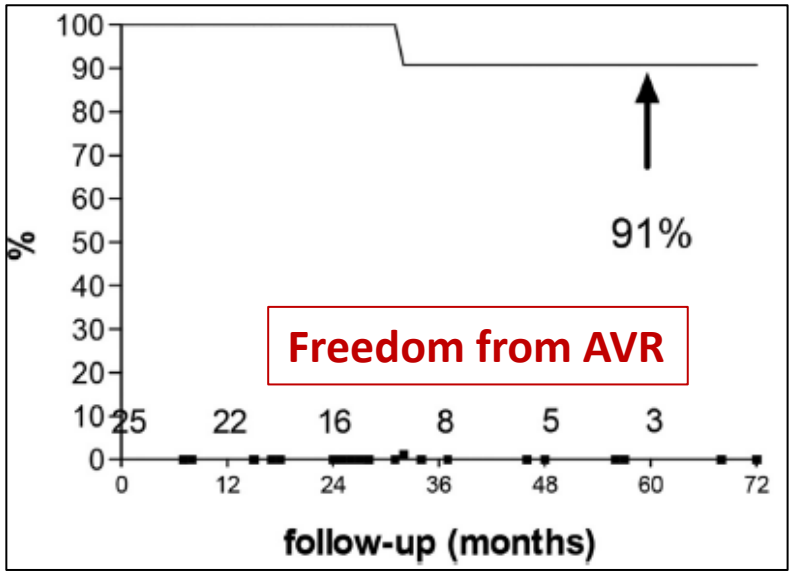
Reoperation
N=0

Unicuspid Valve Repair

Root Remodeling and Aortic Valve Repair for Unicuspid Aortic Valve

Marco Franciulli, MD, Diana Aicher, MD, Tanja Rädle-Hurst, MD, Hiroaki Takahashi, MD, PhD, Svetlana Rodionycheva, MD, and Hans-Joachim Schäfers, MD, PhD





Franciulli et al. Ann Thorac Surg 2014

CONCLUSION

- The rationale behind AV repair and the Ross procedure is the same - **A living aortic valve**
- AV repair and the Ross procedure are **integral and complementary parts** of the management of patients with AI
- **AV repair should be favored** whenever possible as a first step
- Remember: REPAIRIBILITY does not always mean DURABILITY
- **A REPAIR SURGEON SHOULD ALSO BE A ROSS SURGEON (*and vice versa)***

i.elhamamsy@icm-mhi.org