-The Living Aortic Valve-

Repair or Else?

Ismail El-Hamamsy, MD PhD

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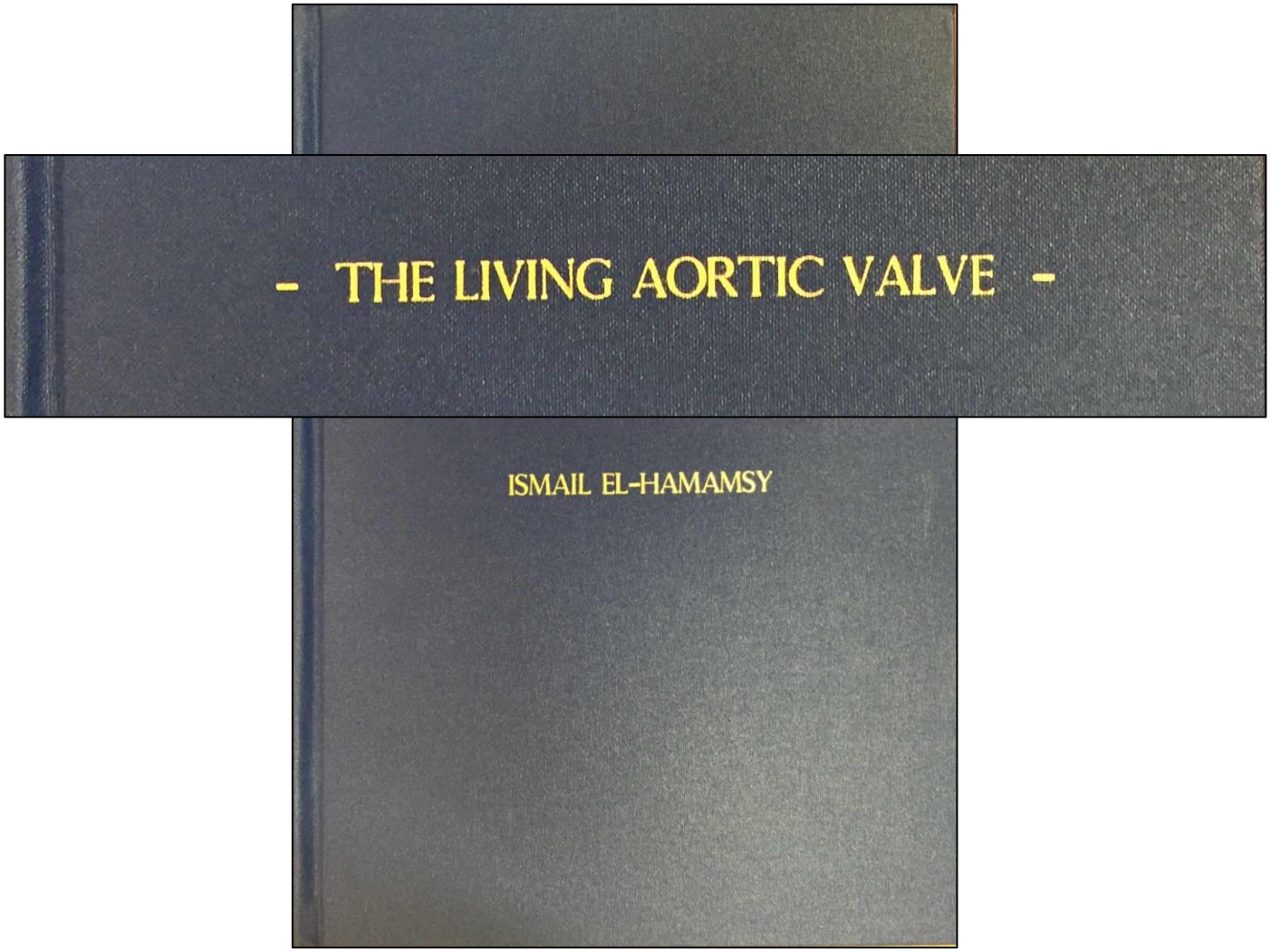
PhD Thesis – Imperial College London (2010)

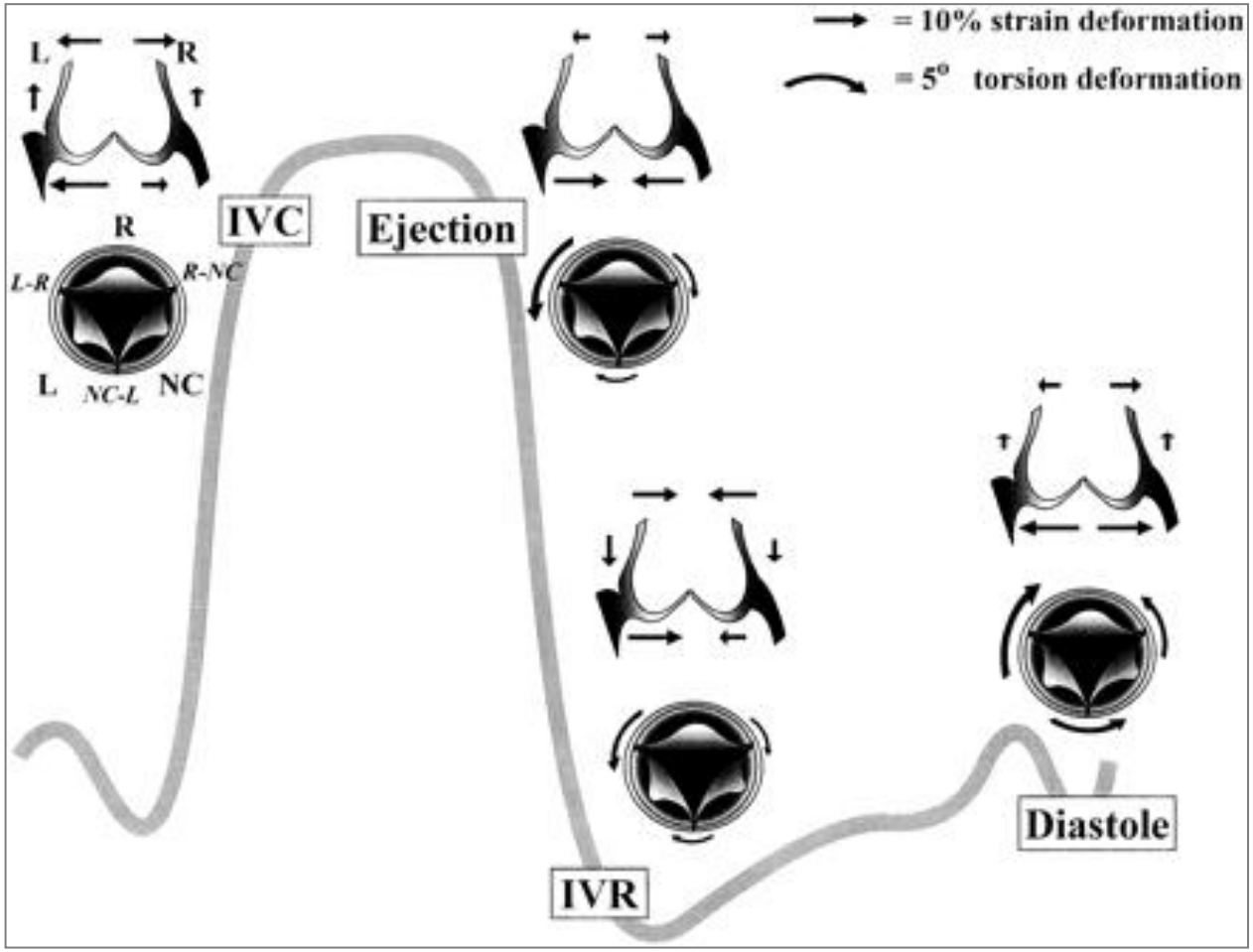


-1-

THE AORTIC ROOT IS

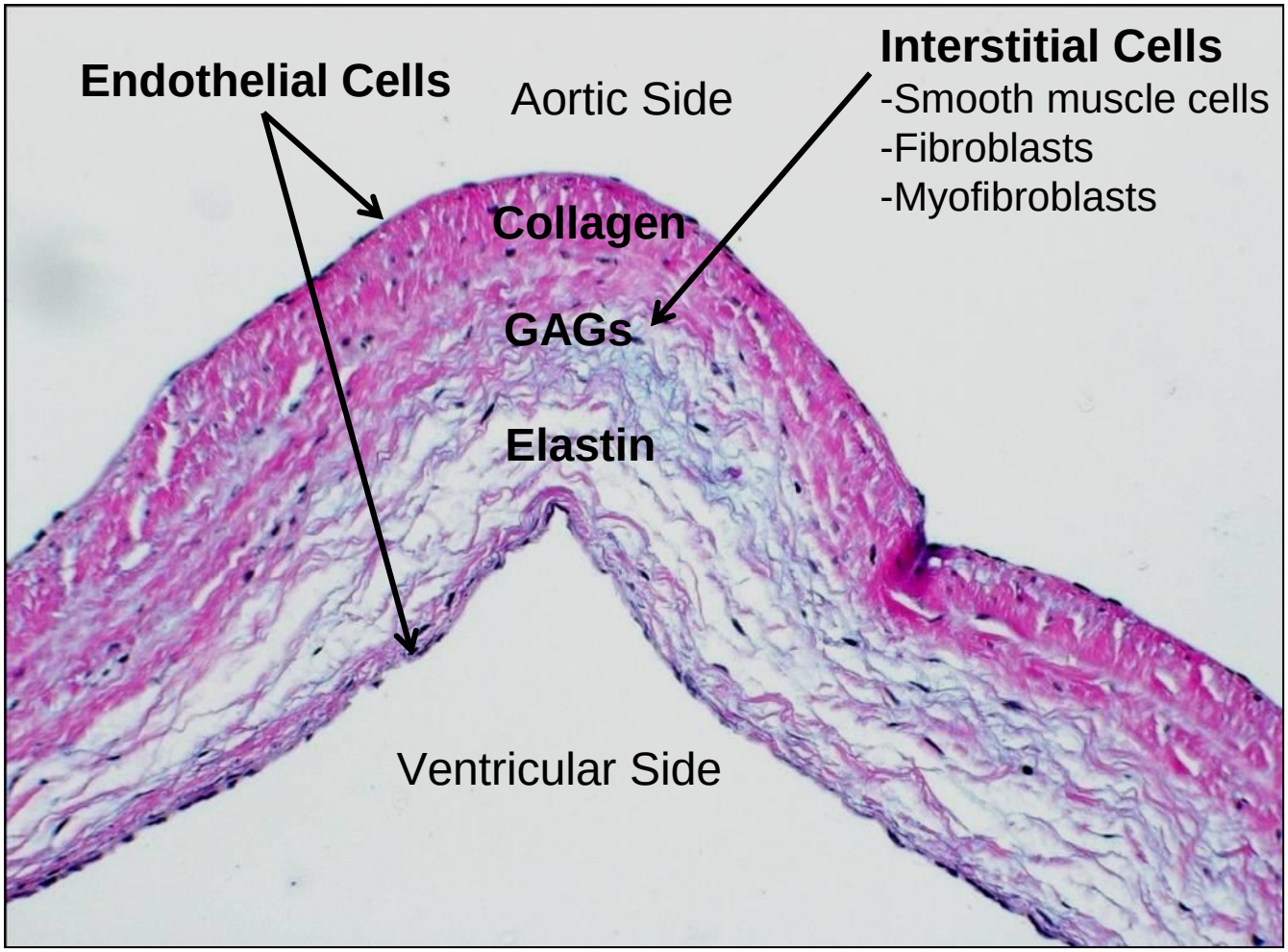
A LIVING STRUCTURE

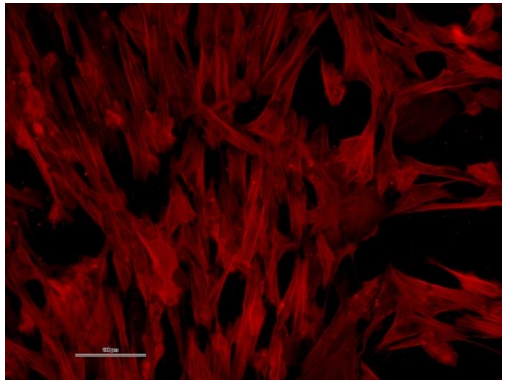
AORTIC ROOT PHYSIOLOGY



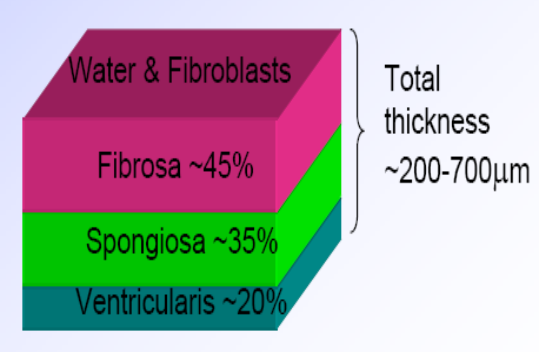
Dagum et al. Circulation 1999

AORTIC VALVE





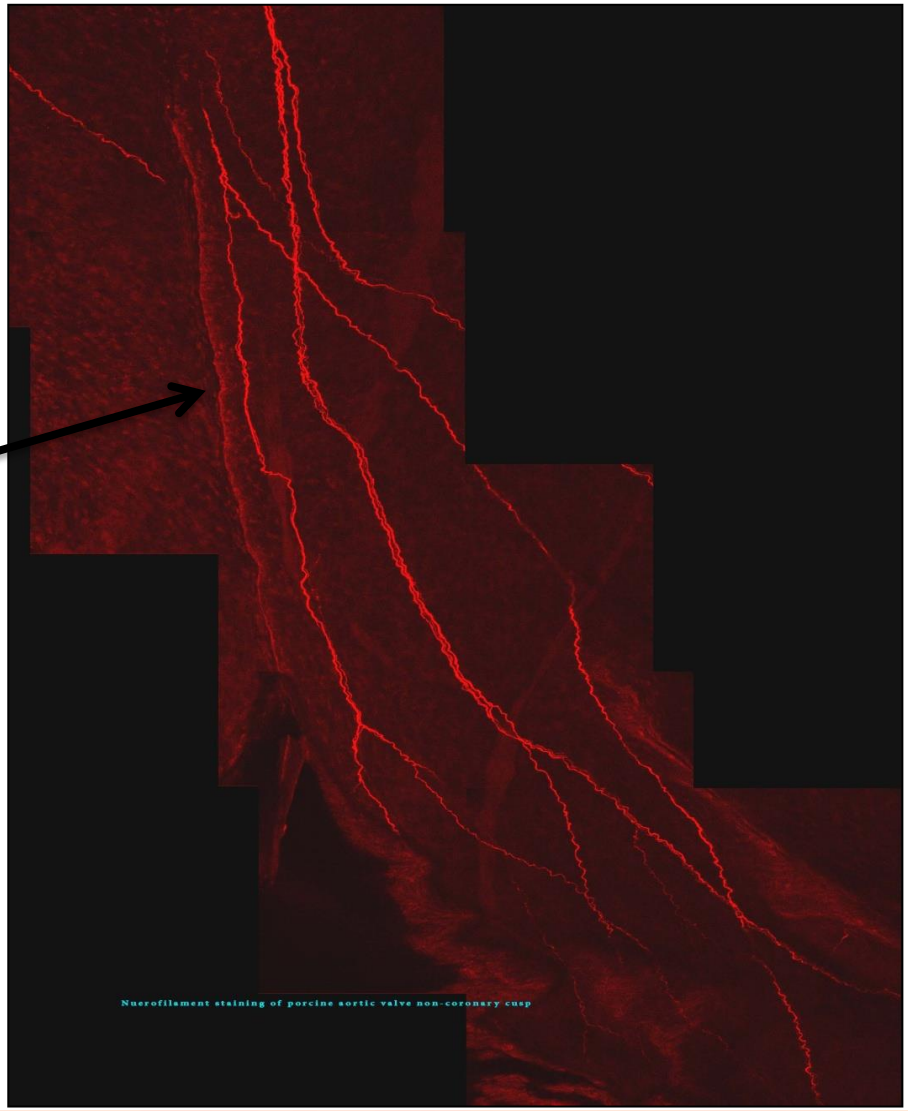
Smooth muscle actin



El-Hamamsy et al. J Adv Res 2009

AORTIC VALVE

Neurofilament

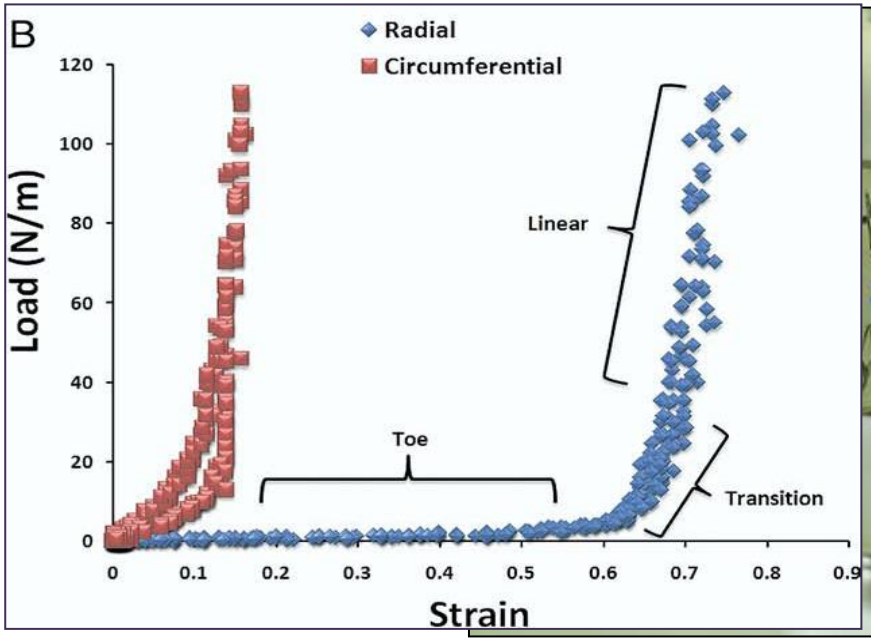


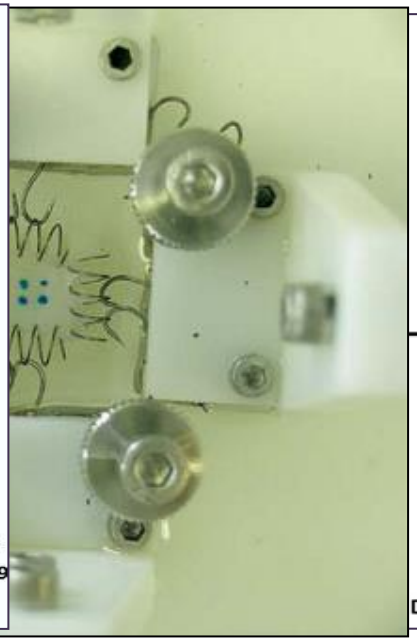
El-Hamamsy et al. Curr Vasc Pharmacol 2009

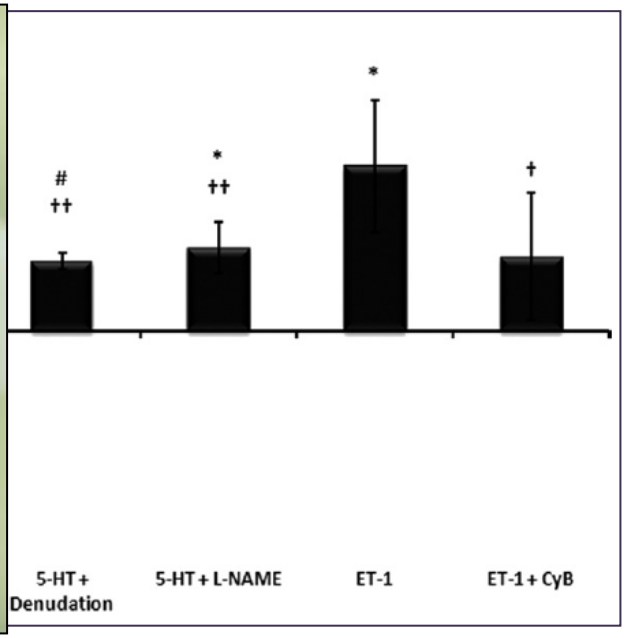
AORTIC VALVE

Endothelium-Dependent Regulation of the Mechanical Properties of Aortic Valve Cusps

Ismail El-Hamamsy, MD,* Kartik Balachandran, MS,† Magdi H. Yacoub, FRS,*
Louis M. Stevens, MD, SM,‡ Padmini Sarathchandra, PHD,* Patricia M. Taylor, PHD,*
Ajit P. Yoganathan, PHD,† Adrian H. Chester, PHD*







El-Hamamsy et al. JACC 2009

THE AORTIC ROOT

LIVING STRUCTURE
=
COMPLEX FUNCTIONS

- Laminar flow
- Excellent hemodynamics
- Low thrombogenicity
- Resistance to infections

OUTCOMES FOLLOWING AVR

Laminar Flow

Thrombogenicity

Survival
Valve-related complications
Quality of life

Hemodynamics (gradients)

Resistance to infections

Rationale

A LIVING AORTIC VALVE SUBSTITUTE

↓

IMPROVED CLINICALLY-RELEVANT OUTCOMES

NON-ELDERLY ADULTS

- **High level of physical activity**
- **Quality of life**
- **Prolonged anticipated life expectancy**

  = Exposure to valve-related complications
  - Degeneration + Reoperation (tissue valves)
  - Bleeding + Thromboembolisms (mechanical valves)

-2-

CONVENTIONAL AVR IN THE YOUNG

=

EXCESS MORTALITY

CONVENTIONAL AVR

SEVERAL ADVANTAGES

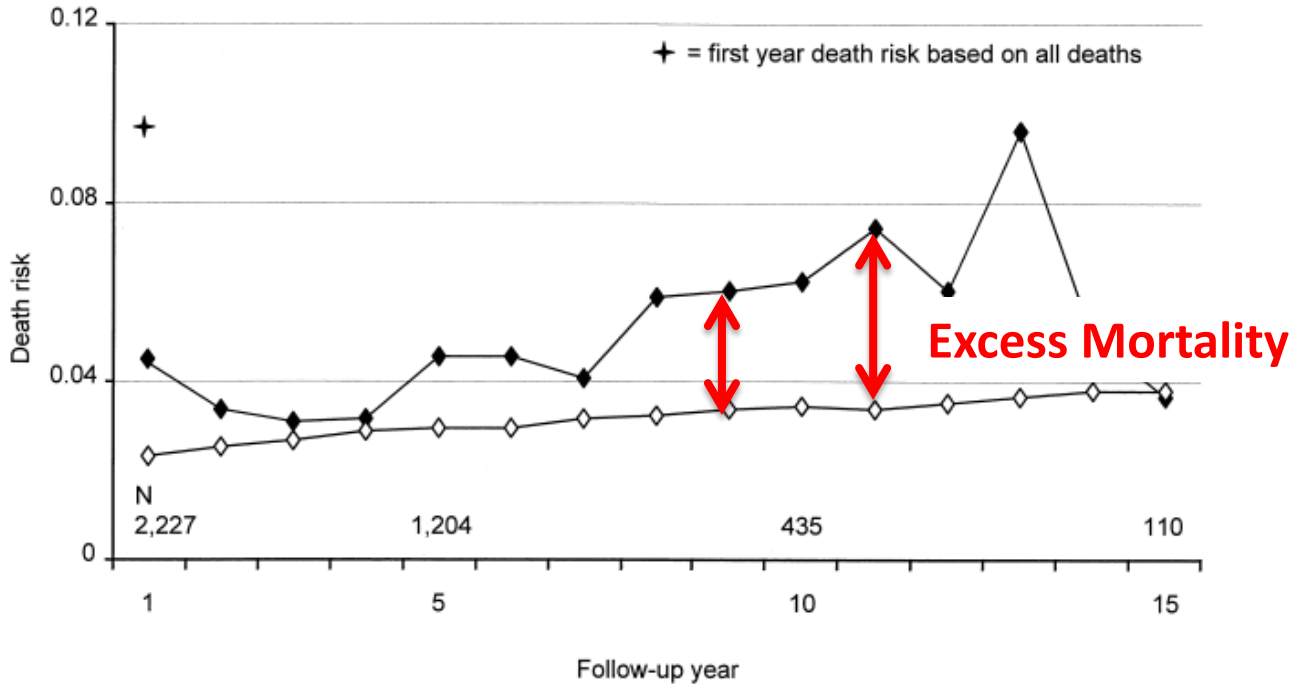
- Standardized
- Easily reproducible
- Short operative times
- Long-term data

AVR IN THE YOUNG

Observed and Relative Survival After Aortic Valve Replacement

Per Kvidal, MD,* Prof. Reinhold Bergström, PHD,‡ Lars-Gunnar Hörte, PM, BA,§ Elisabeth Ståhle, MD, PHD†

Uppsala and Stockholm, Sweden



Kvidal et al. JACC 2000

AVR IN THE YOUNG

Table 4. Basic Data Concerning Observed and Expected Deaths Based on Data From Follow-Up Years 1 through 15*

	Patient-Years at Risk	Observed Number of Deaths	Expected Number of Deaths	O/E Deaths
Age (yrs)				
≤50	2,182	31	6.8	4.5
51–60	2,954.5	98	36.9	2.7
61–70	5,578.5	274	152.1	1.8
≥71	3,579	212	208.2	1.0

The younger the patients are,
The higher excess mortality is

Kvidal et al. JACC 2000

MECHANICAL AVR IN THE YOUNG

Long-term outcomes after elective isolated mechanical aortic valve replacement in young adults

Ismail Bouhout, MSc,[a] Louis-Mathieu Stevens, MD, PhD,[b] Amine Mazine, MSc,[a] Nancy Poirier, MD,[a] Raymond Cartier, MD,[a] Philippe Demers, MD,[a] and Ismail El-Hamamsy, MD, PhD[a]

1997-2006: 469 isolated mechanical AVR <65 years

Mean follow-up: 9.1 ± 3.5 years

Follow-up 95% complete (4099 patient-years)

Mean age: 53.2 ± 9.2

Bouhout et al. JTCVS 2014

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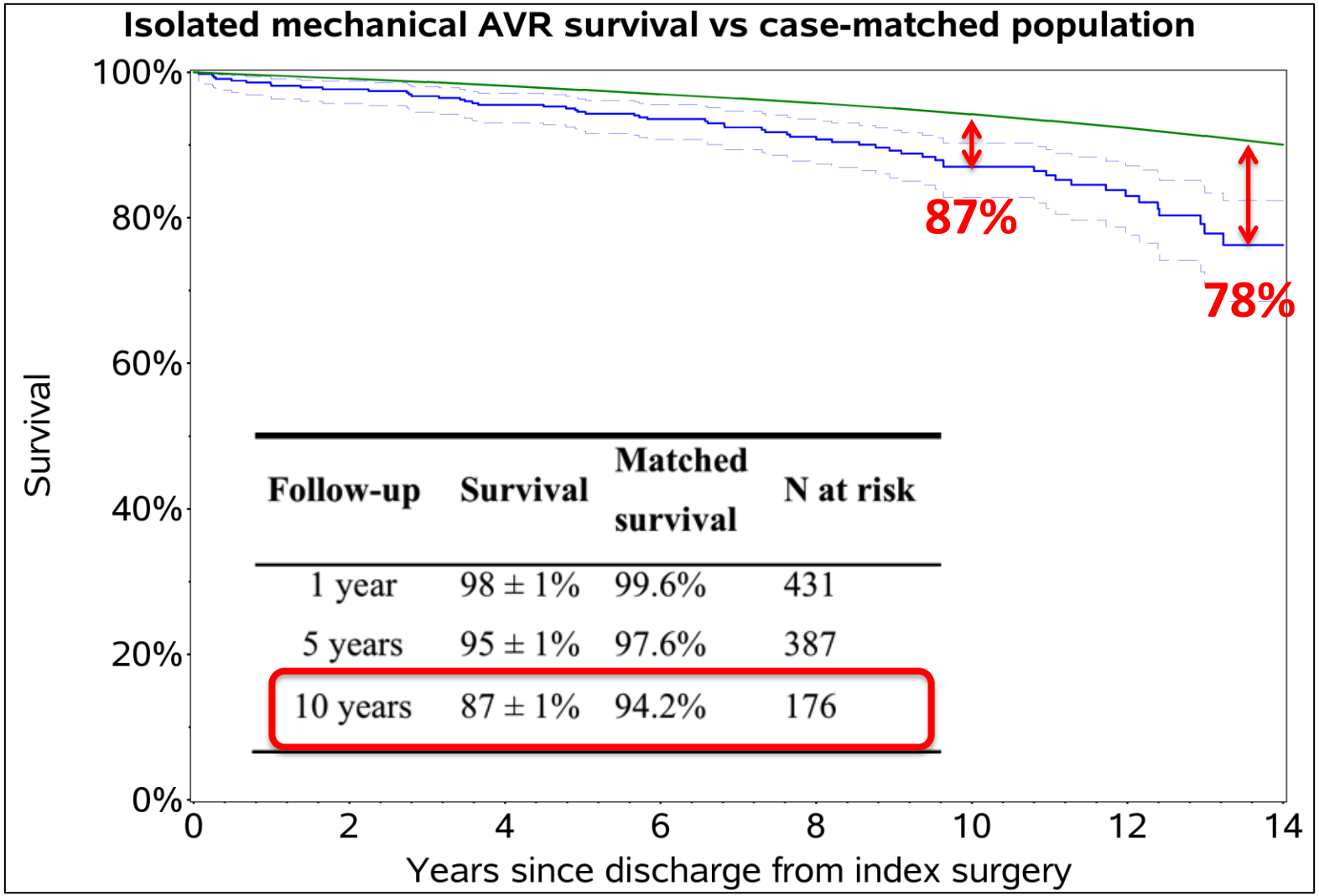
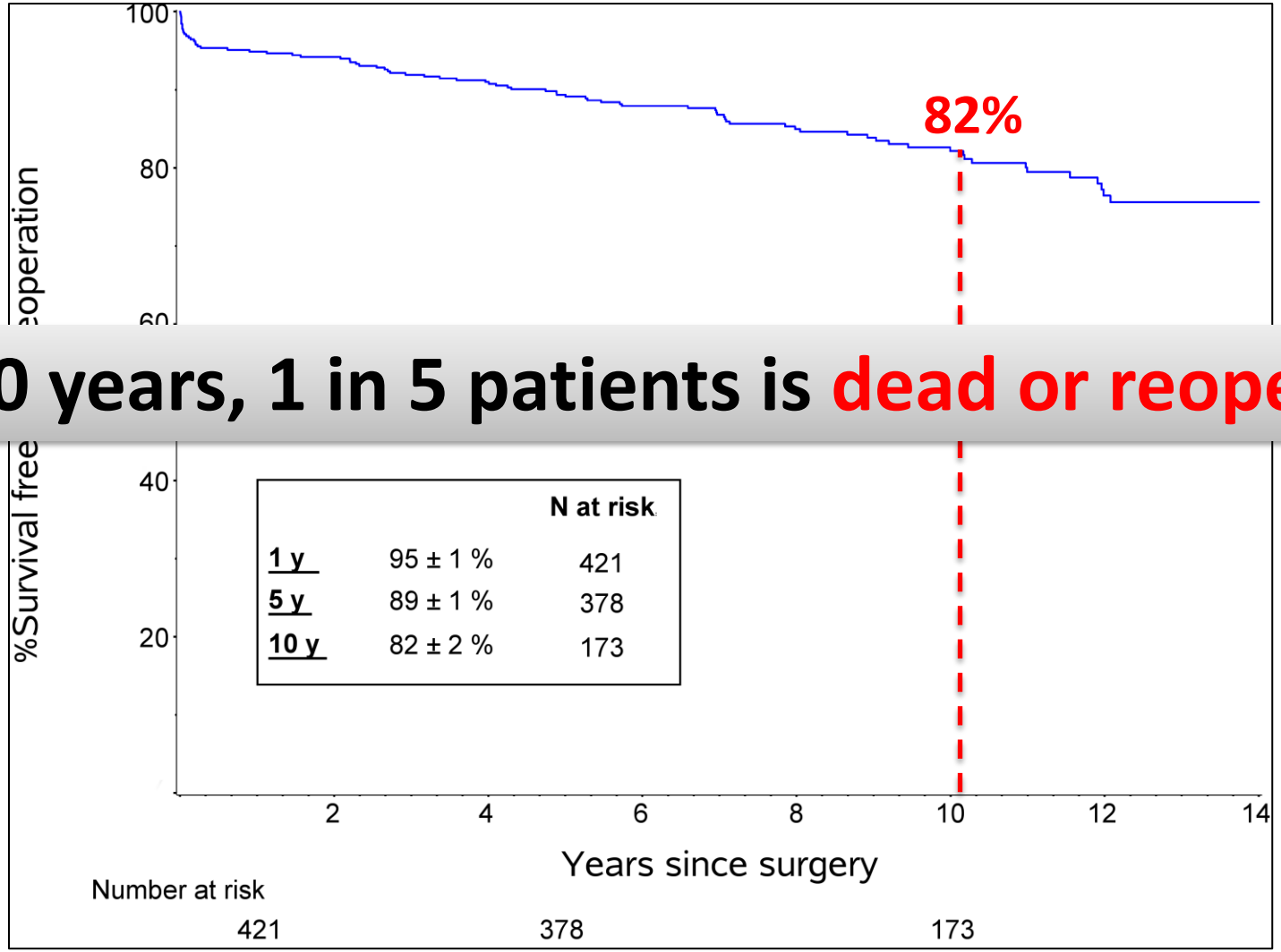
SURVIVAL – MECHANICAL AVR



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

SURVIVAL FREE FROM REOPERATION



A 10 years, 1 in 5 patients is dead or reoperated

Bouhout et al. JTCVS 2014

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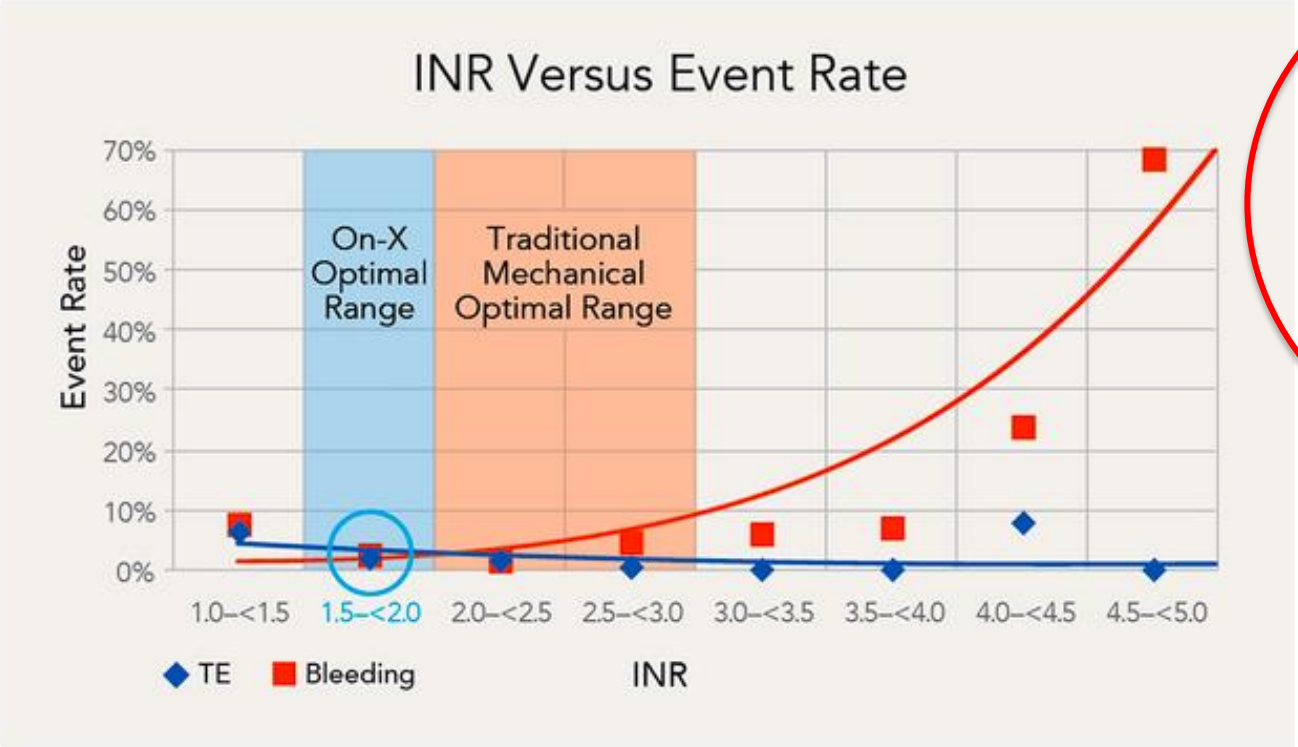
Valve-Related Complications

On-X aortic heart valves

INR: 1.5–2.0 | Design | PROACT | Con

PROACT RESULTS

Prospective Randomized On-X Valve Anticoagulation Clinical Trial



- 65% Fewer Bleeds
- No Increase in TE
- INR: 1.5–2.0
- 63,000 INR Data Points
- 33 US Centers

Learn More

» Read the article at JTCVS

» Watch the slide presentation

» Request more information

PROACT Trial (n=375 pts)

AVR High-risk postrandomization event comparisons

	Test group (pt-yr = 766.2)		Control group (pt-yr = 878.6)				
Primary Event	**Patients (n)**	**Rate (%/pt-yr)**	**Patients (n)**	**Rate (%/pt-yr)**	**Rate Ratio (test/ctrl)**	**95% CI**	***P*-value**
Bleeding							
Major	**12**	**1.57**	**34**	**3.87**	**0.40**	**0.21-0.78**	**0.007**
Hemorrhagic stroke	1	0.13	4	0.46	0.29	0.03-2.56	0.264
Minor	**9**	**1.17**	**35**	**3.98**	**0.29**	**0.14-0.61**	**0.001**
Total	**21**	**2.74**	**69**	**7.85**	**0.35**	**0.21-0.57**	**<0.001**
Ischemic stroke	6	0.78	7	0.80	0.98	0.33-2.92	0.975
TIA	11	1.44	7	0.80	1.80	0.70-4.65	0.223
Neurologic event	17	2.22	14	1.59	1.39	0.69-2.82	0.359
Peripheral TE	4	0.52	1	0.11	4.59	0.51-41.04	0.173
All TE	21	2.74	15	1.71	1.61	0.88-3.11	0.161
Thrombosis	2	0.26	2	0.23	1.15	0.16-8.14	0.891
Major event (major bleeding, all TE, thrombosis)	35	4.57	51	5.80	0.79	0.51-1.21	0.275
Primary endpoint	**44**	**5.74**	**86**	**9.79**	**0.59**	**0.41-0.84**	**0.004**

Puskas et al. JTCVS 2014

TISSUE AVR IN THE YOUNG

Survival after valve replacement for aortic stenosis: Implications for decision making

Tomislav Mihaljevic, MD,[a] Edward R. Nowicki, MD,[a] Jeevanantham Rajeswaran, MSc,[b] Eugene H. Blackstone, MD,[a,b] Luigi Lagazzi, MD,[a] James Thomas, MD,[c] Bruce W. Lytle, MD,[a] and Delos M. Cosgrove, MD[a]

3,049 Perimount patients; 1991-2004

". . .younger patients had worse than expected survival that was further diminished with insertion of a small prosthesis."

Mihajlevic et al. JTCVS 2008

TISSUE AVR IN THE YOUNG

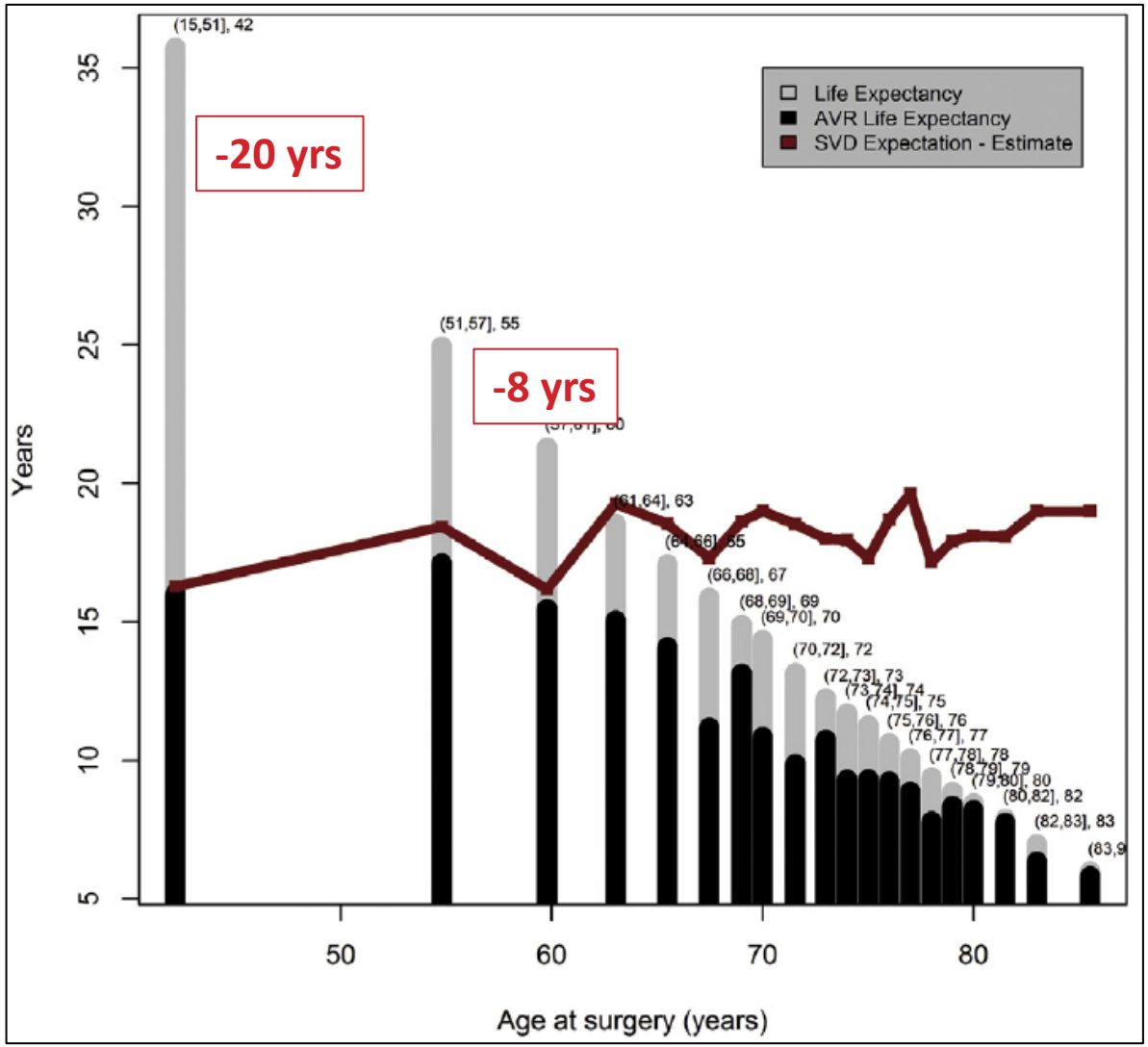
Very Long-Term Outcomes of the Carpentier-Edwards Perimount Valve in Aortic Position

Thierry Bourguignon, MD, Anne-Lorraine Bouquiaux-Stablo, MD, Pascal Candolfi, PhD, Alain Mirza, MD, Claudia Loardi, MD, Marc-Antoine May, MD, Rym El-Khoury, MD, Michel Marchand, MD, and Michel Aupart, MD

2,659 Perimount patients; 1984-2008

Bourguignon et al. Ann Thorac Surg 2015

Excess Mortality in Young Adults

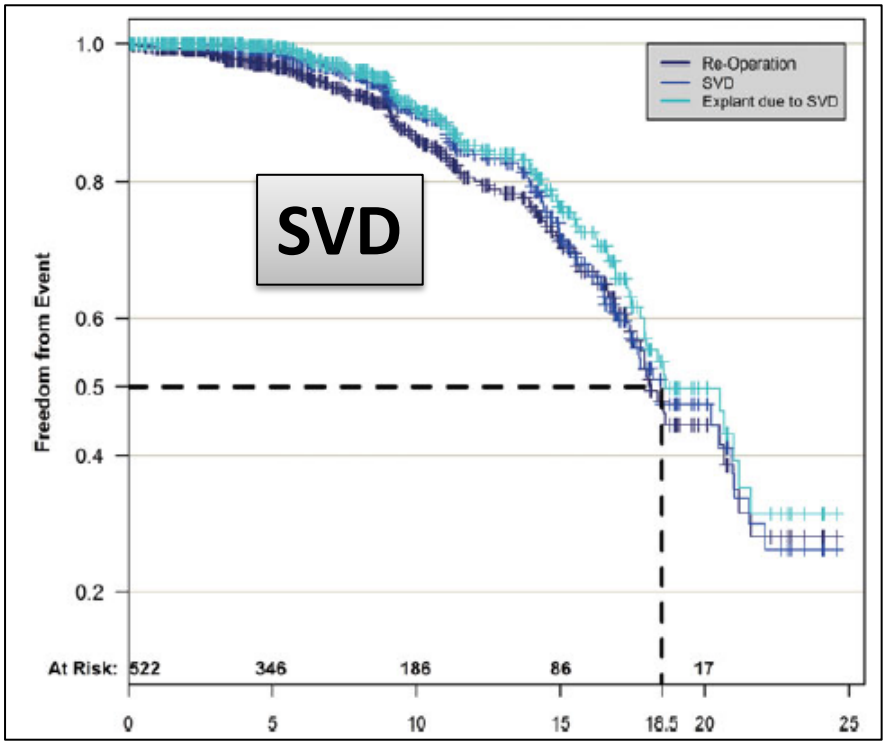


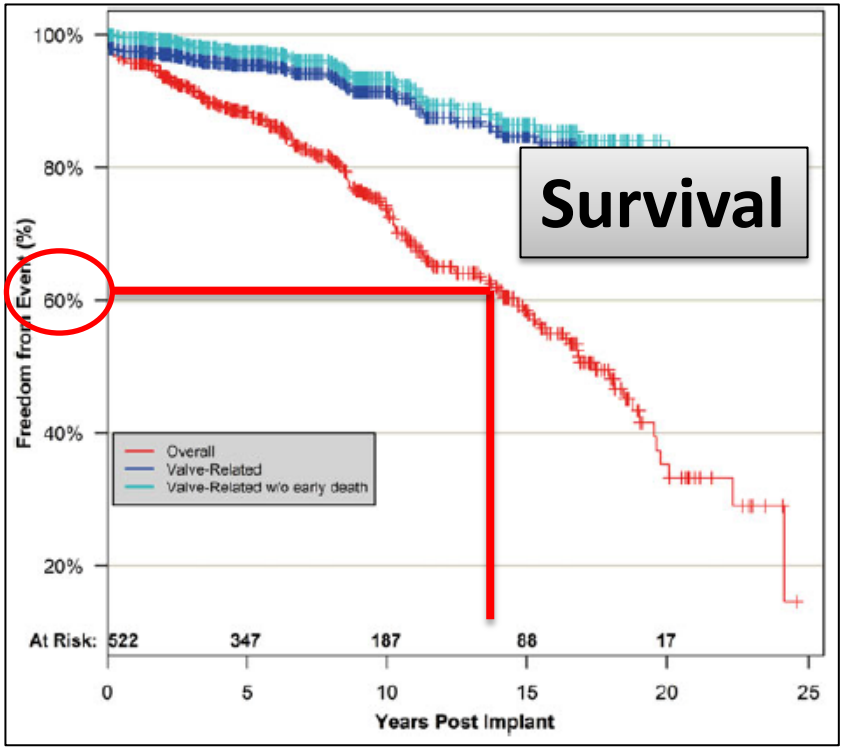
Bourguignon et al. Ann Thorac Surg 2015

SVD and Death = Competing Risks

Very long-term outcomes of the Carpentier-Edwards Perimount aortic valve in patients aged 50–65 years†

Thierry Bourguignon[a,*], Pierre Lhommet[a], Rym El Khoury[a], Pascal Candolfi[b], Claudia Loardi[a], Alain Mirza[a], Julie Boulanger-Lothion[a], Anne-Lorraine Bouquiaux-Stablo-Duncan[a], Michel Marchand[a] and Michel Aupart[a]





Bourguignon et al. Eur J Cardiothorac Surg 2016

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AVR IN THE YOUNG

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

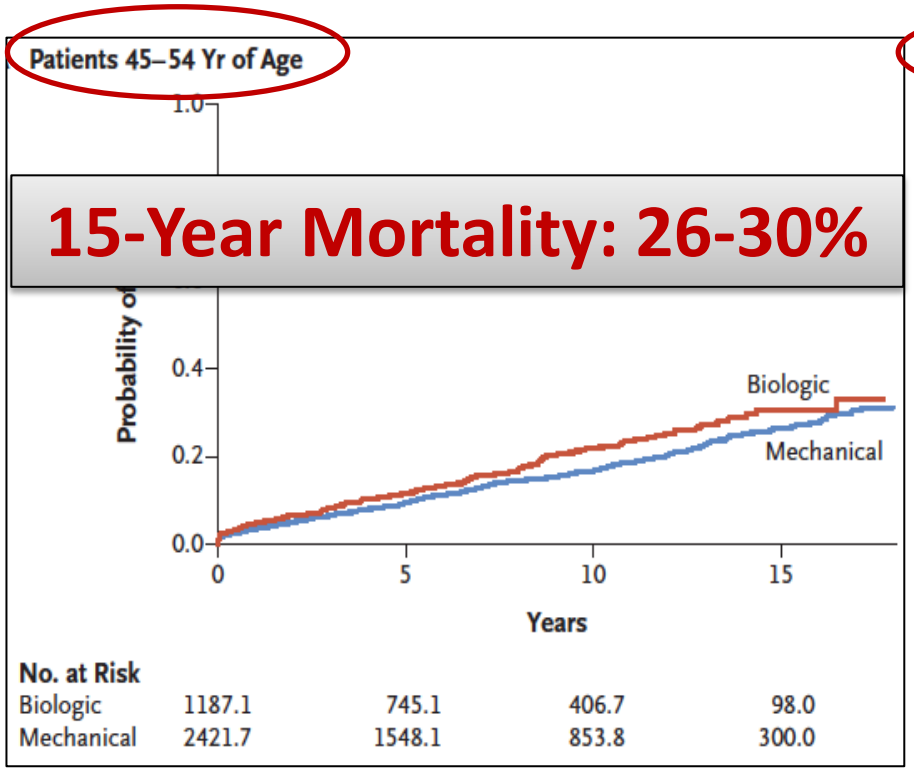
Mechanical or Biologic Prostheses for Aortic-Valve and Mitral-Valve Replacement

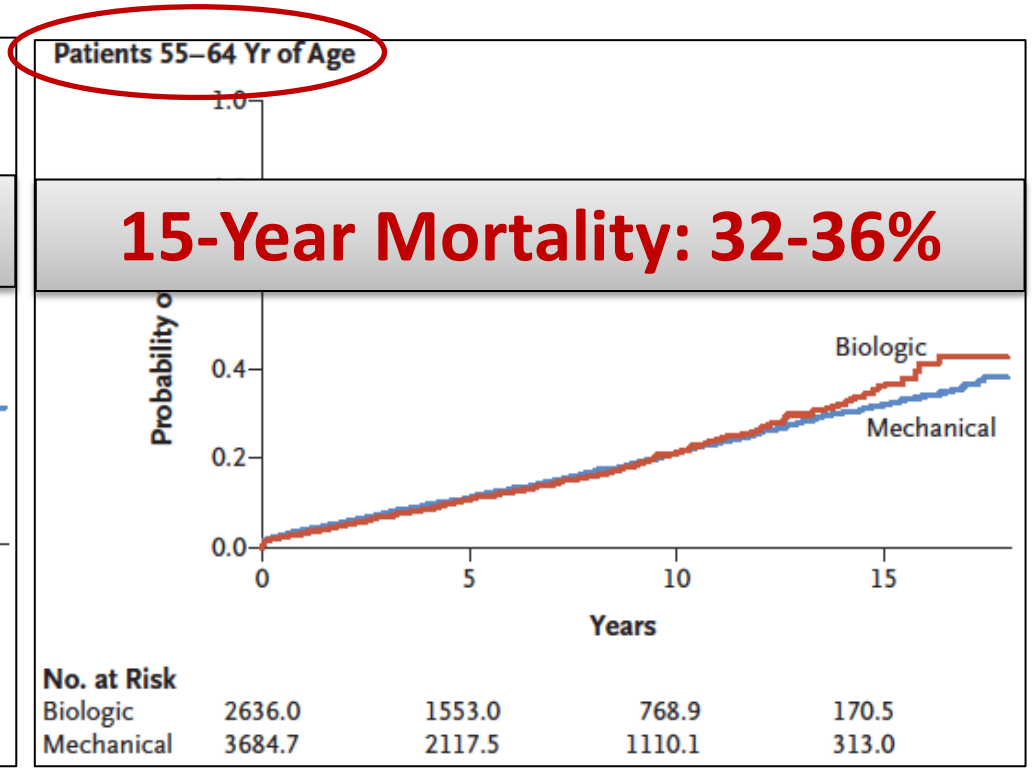
Andrew B. Goldstone, M.D., Ph.D., Peter Chiu, M.D., Michael Baiocchi, Ph.D., Bharathi Lingala, Ph.D., William L. Patrick, M.D., Michael P. Fischbein, M.D., Ph.D., and Y. Joseph Woo, M.D.

9,942 isolated AVR <65 years; 1996-2013

Goldstone et al. NEJM 2017

AVR IN THE YOUNG





Goldstone et al. NEJM 2017

CONVENTIONAL AVR IN THE YOUNG

~~CURATIVE~~

PALLIATIVE

EXCESS MORTALITY IS OBSERVED

UP TO 60 YEARS OF AGE

AT THE TIME OF SURGERY

A LIVING AORTIC VALVE

=

IMPROVED OUTCOMES?

-3-

ROSS PROCEDURE =

IMPROVED CLINICAL OUTCOMES

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 anti-microbial 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

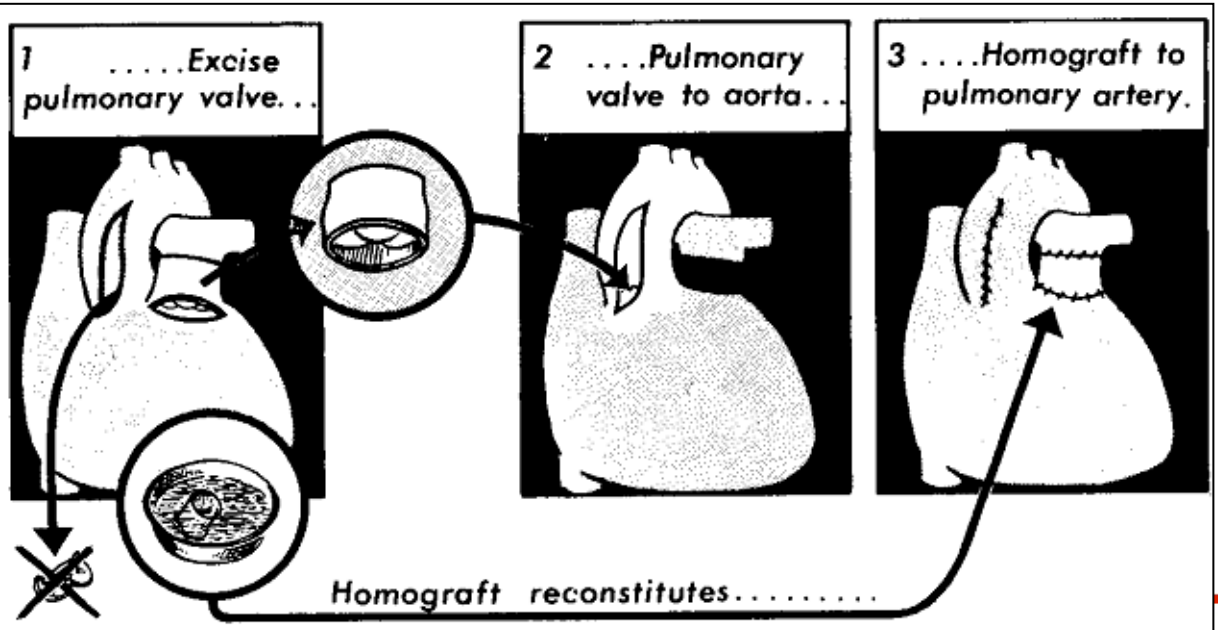


Fig. 3—Steps in replacement of aortic valve with a pulmonary autograft.

Historical Perspective

REPLACEMENT OF THE AORTIC VALVE
WITH THE AUTOLOGOUS PULMONIC VALVE

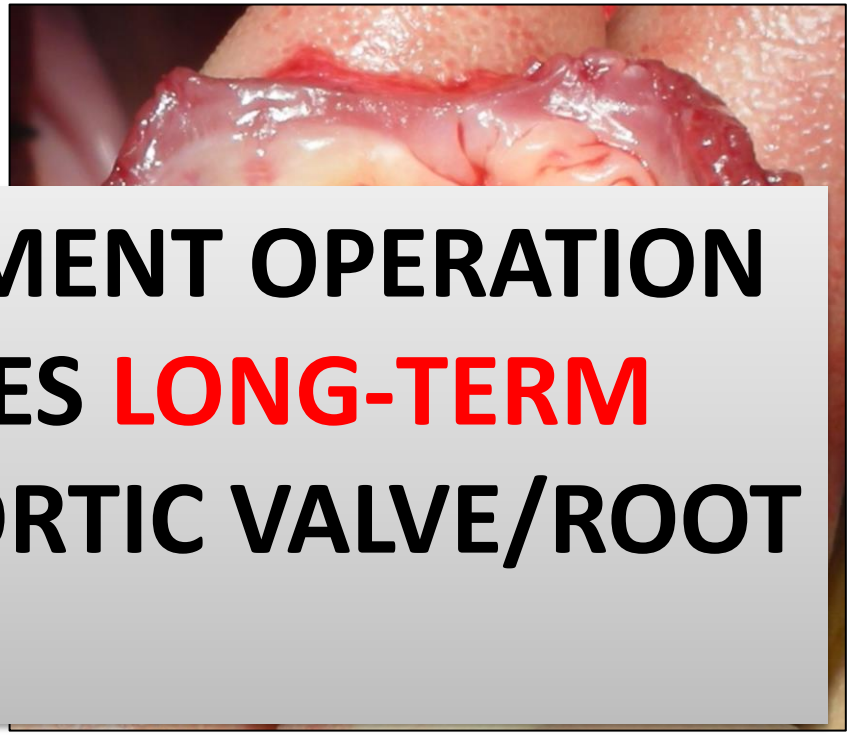
R. CREE PILLSBURY, M.D. AND
NORMAN E. SHUMWAY, M.D., F.A.C.S.

DISEASED HEART VALVES are now readily replaced with a low operative mortality; however, continuing morbidity and mortality make

From the Stanford University School of Medicine, Division of Cardiovascular Surgery, Palo Alto, Calif.

Surgical Forum 1965

ROSS PROCEDURE



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

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

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

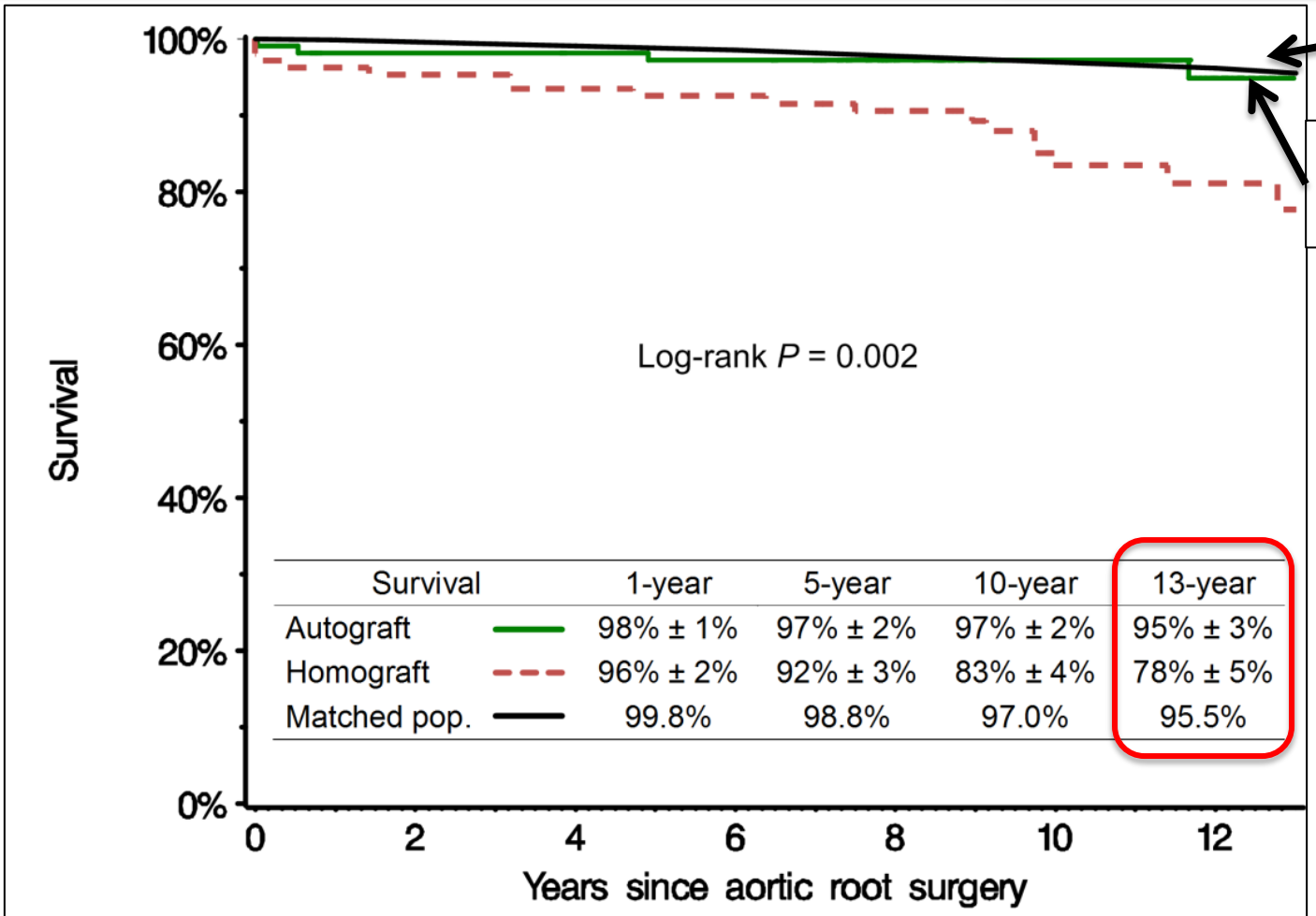
Ismail El-Hamamsy, Zeynep Eryigit, Louis-Mathieu Stevens, Zubair Sarang, Robert George, Lucy Clark, Giovanni Melina, Johanna J M Takkenberg, Magdi H Yacoub

	Homograft (n=108)	Autograft (n=108)
Age (years; median, range)	39 (19–68)	38 (19–66)
Smoker	23 (21%)	18 (17%)
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)		
Endocarditis		
None	86 (80%)	89 (82%)
Active	9 (8%)	9 (8%)
Treated	13 (12%)	10 (9%)
Rheumatic	6 (6%)	7 (6%)
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%)
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

ROSS

GENERAL POPULATION

El-Hamamsy et al. Lancet 2010

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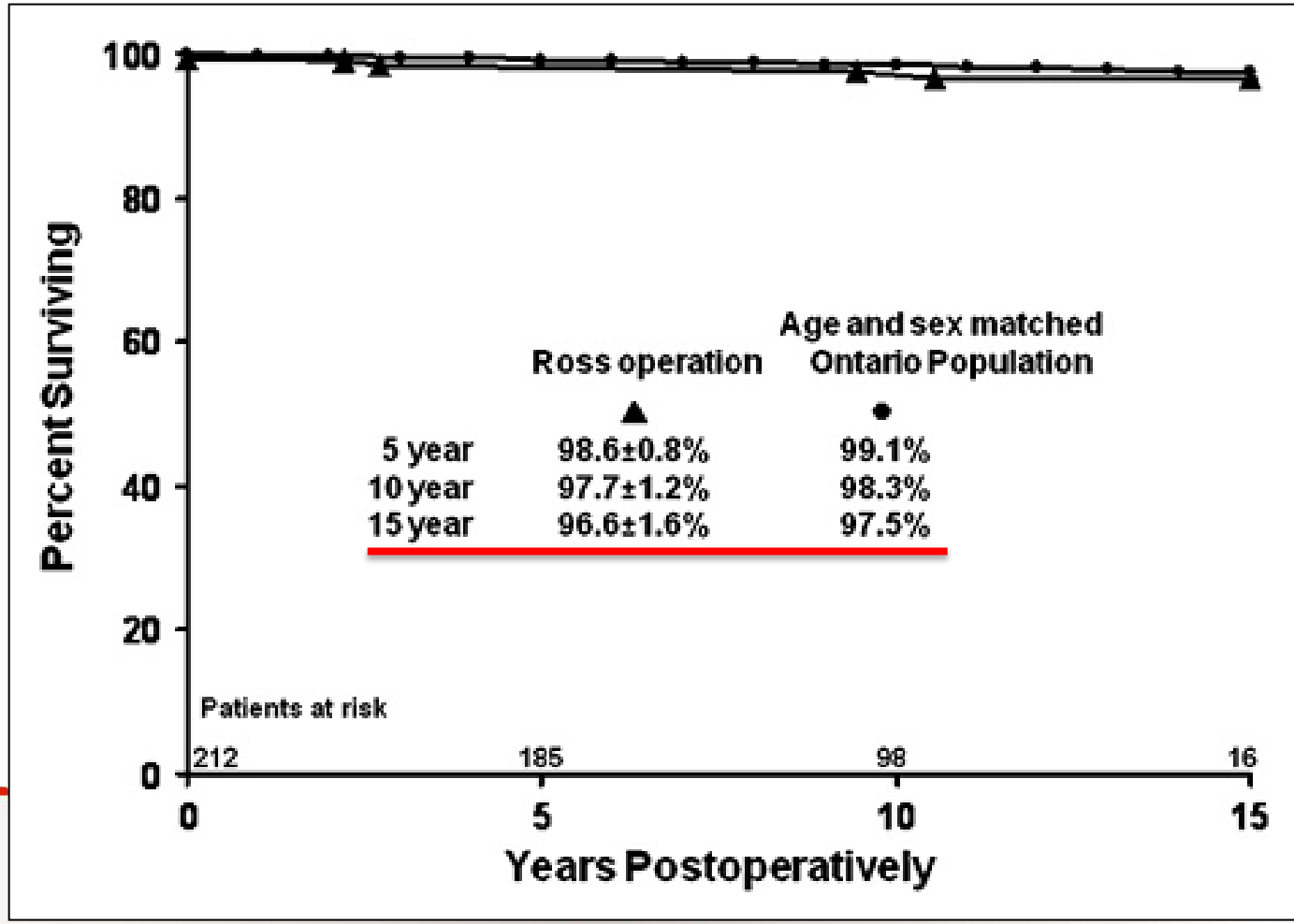
SURVIVAL - ROSS

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 yrs**



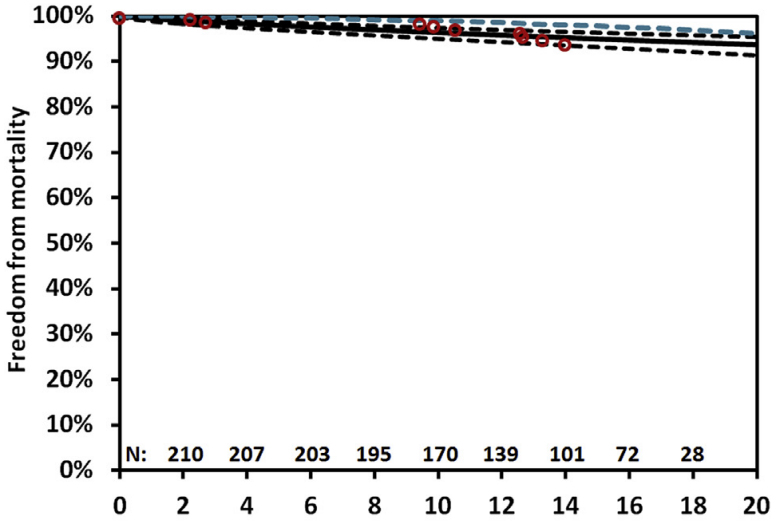
David et al. JTCVS 2010

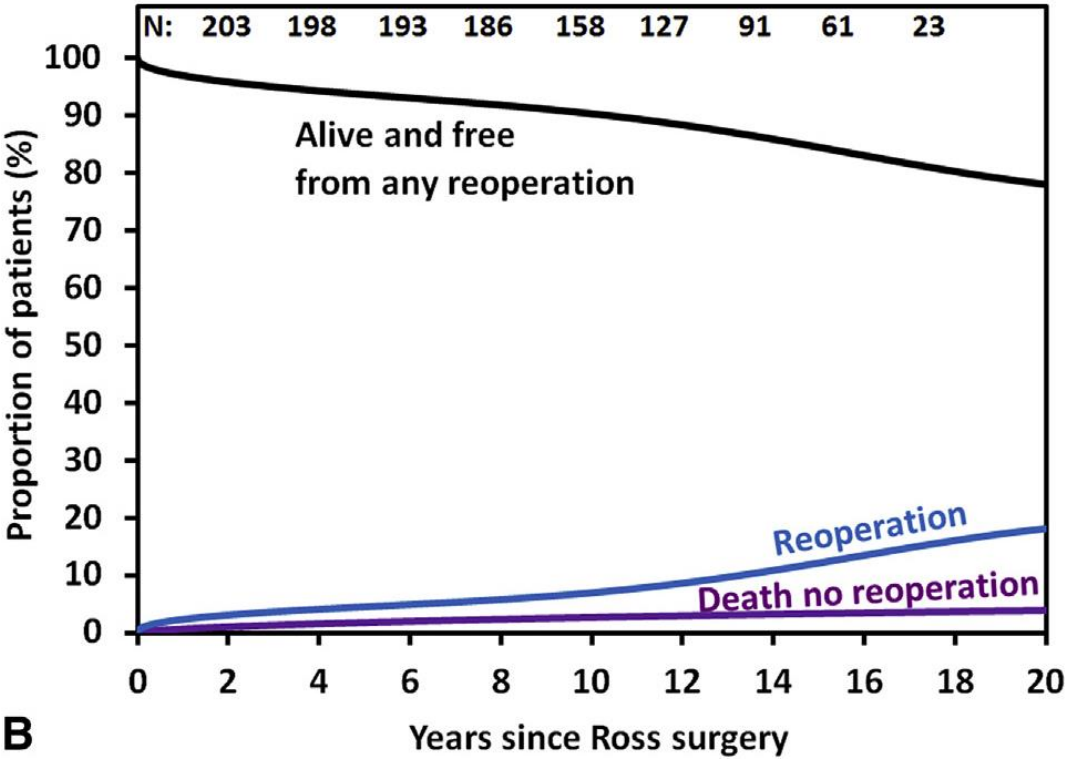
SURVIVAL - ROSS

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**



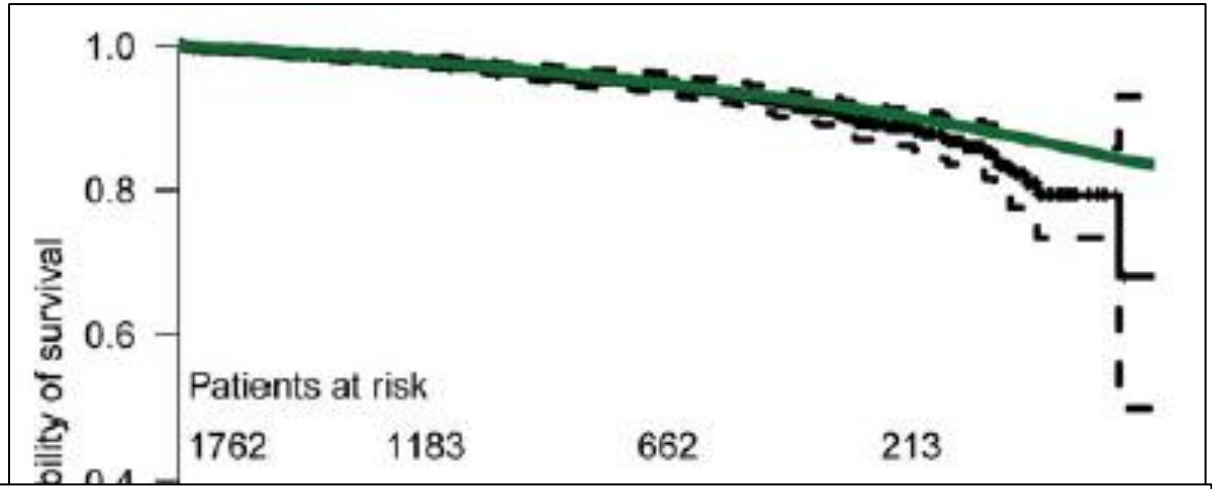


David et al. JTCVS 2014

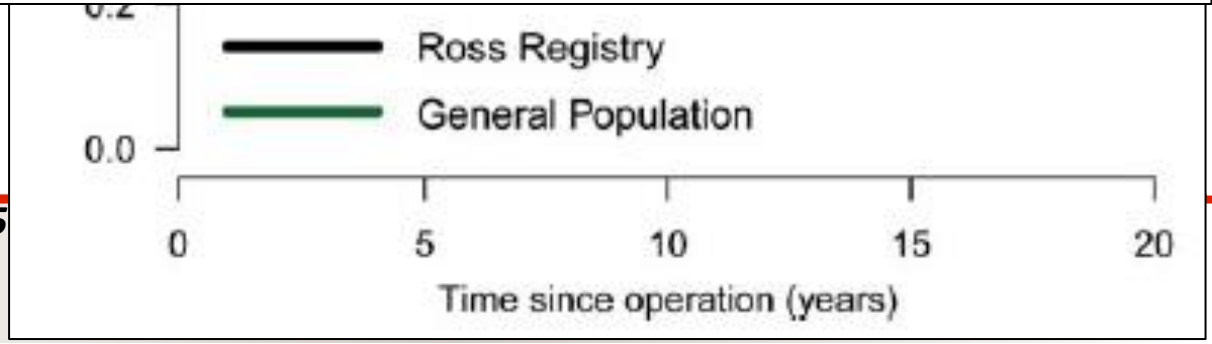
SURVIVAL

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.



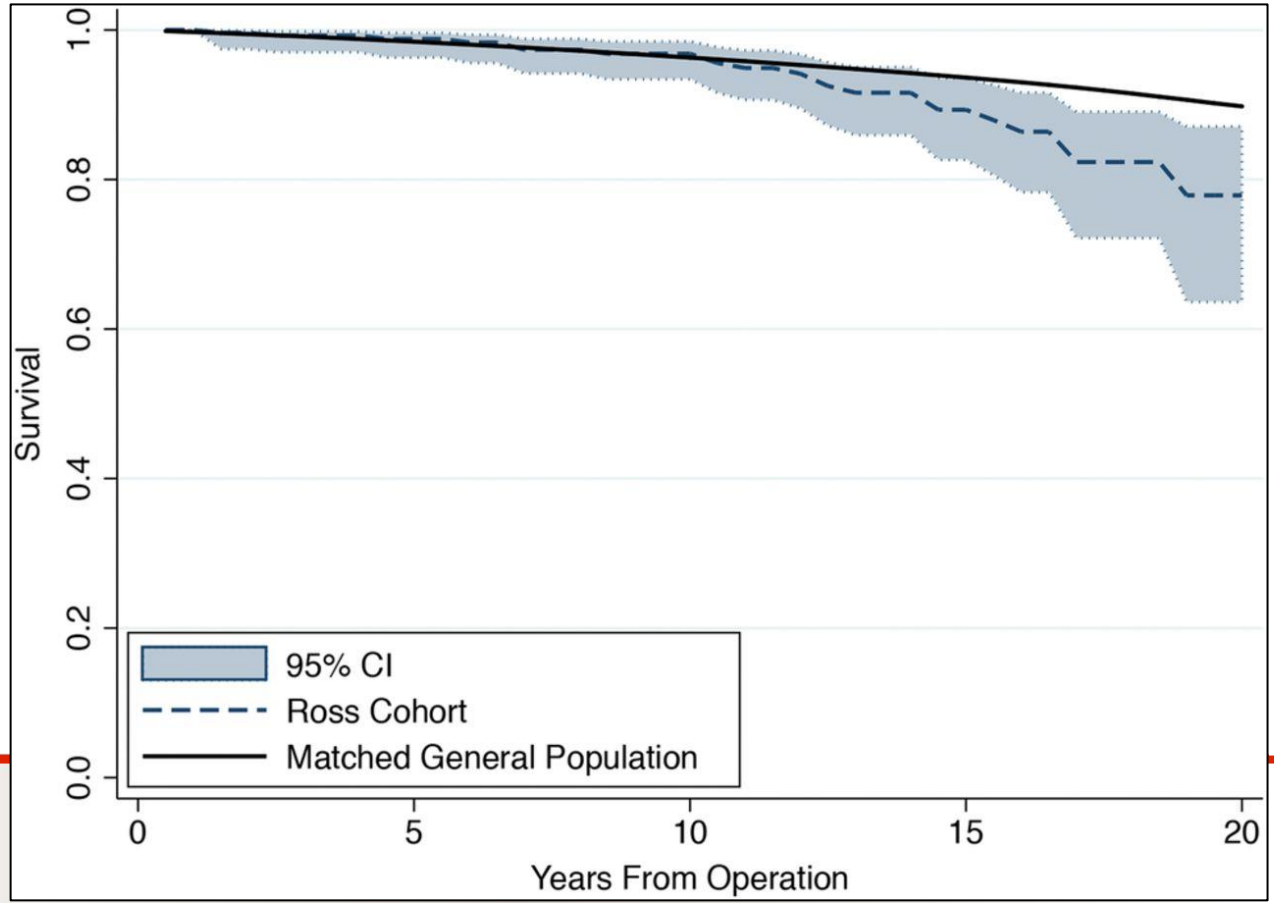
Sievers et al. Eur J Cardiothor Surg 2015

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**



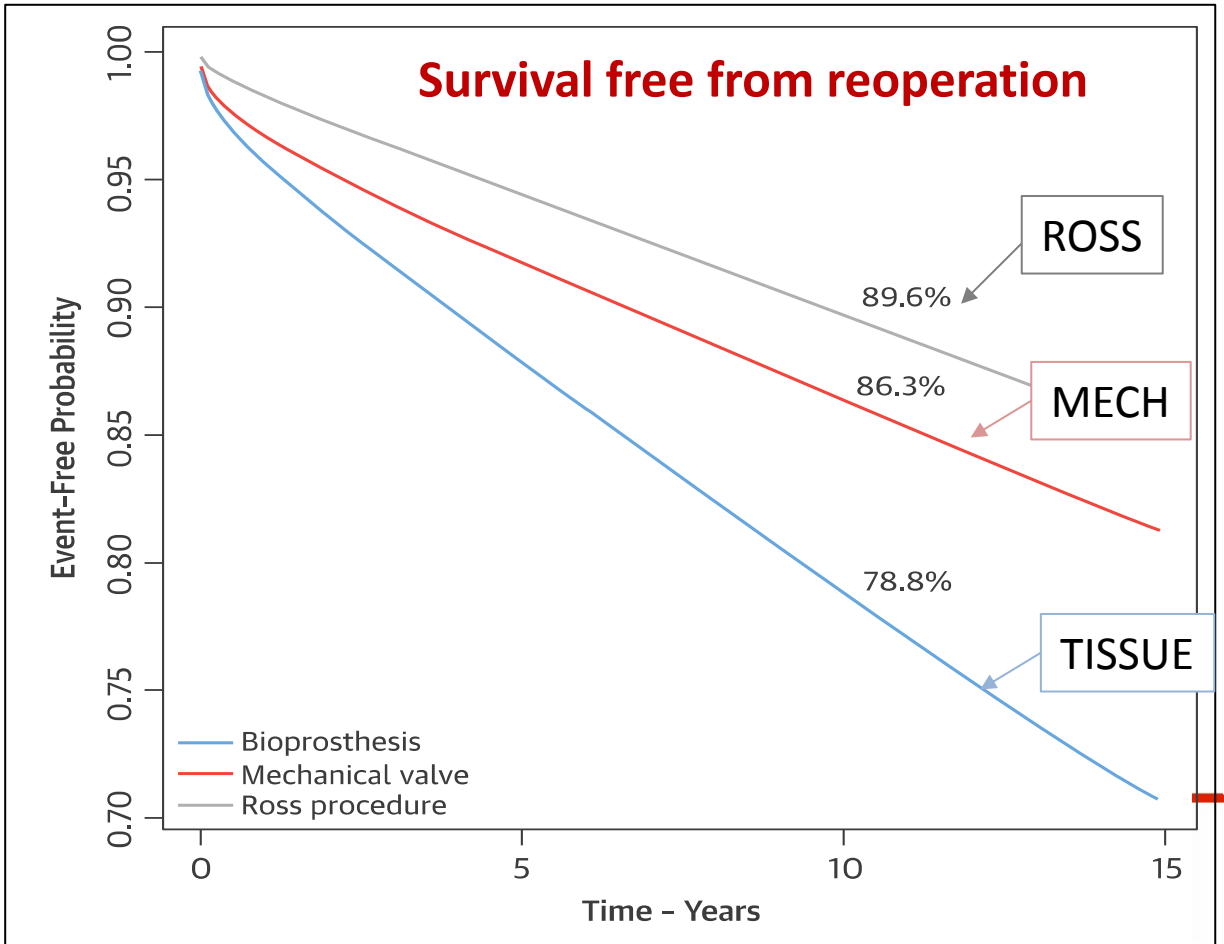
Mastrobuoni, EJCTS 2015

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**



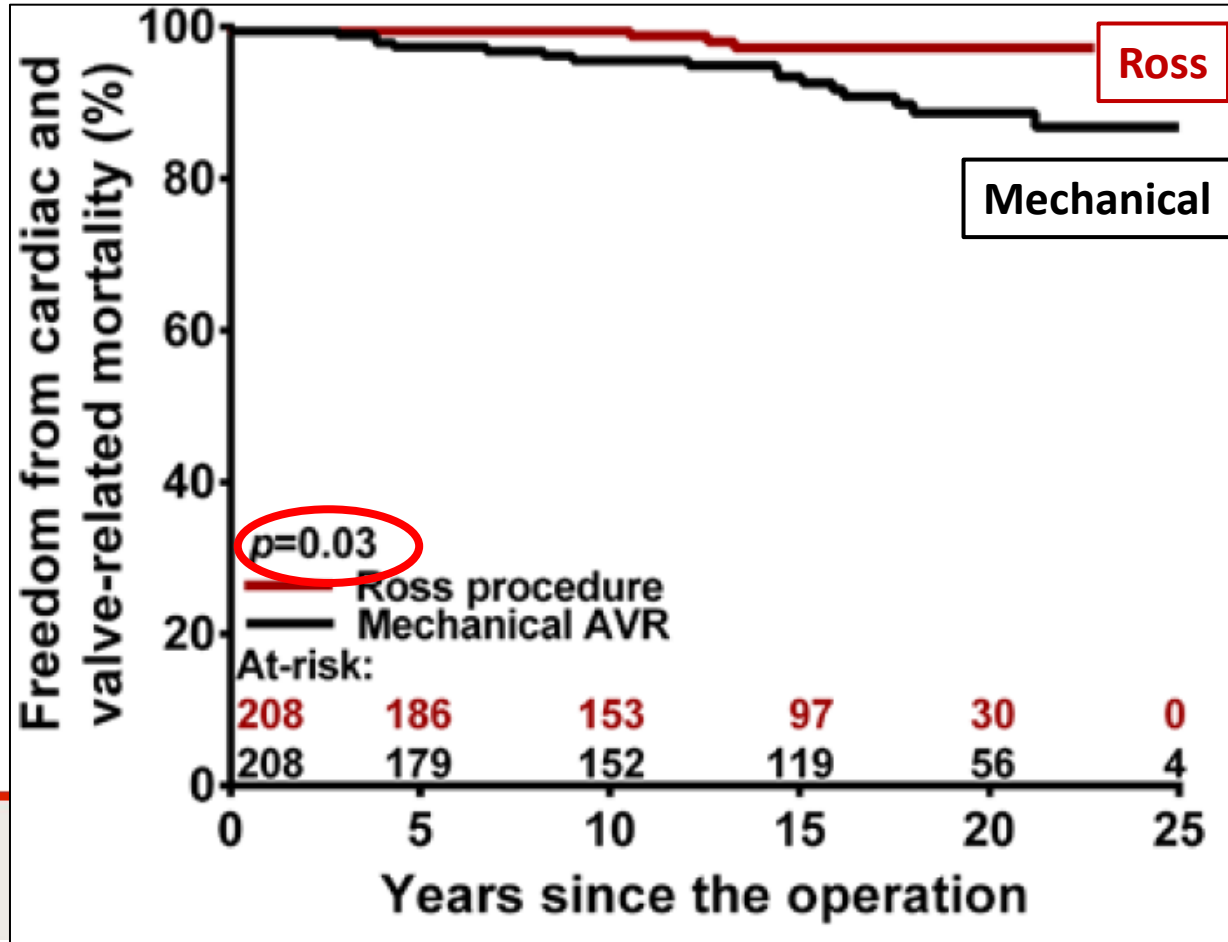
Sharabiani et al. JACC 2016

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



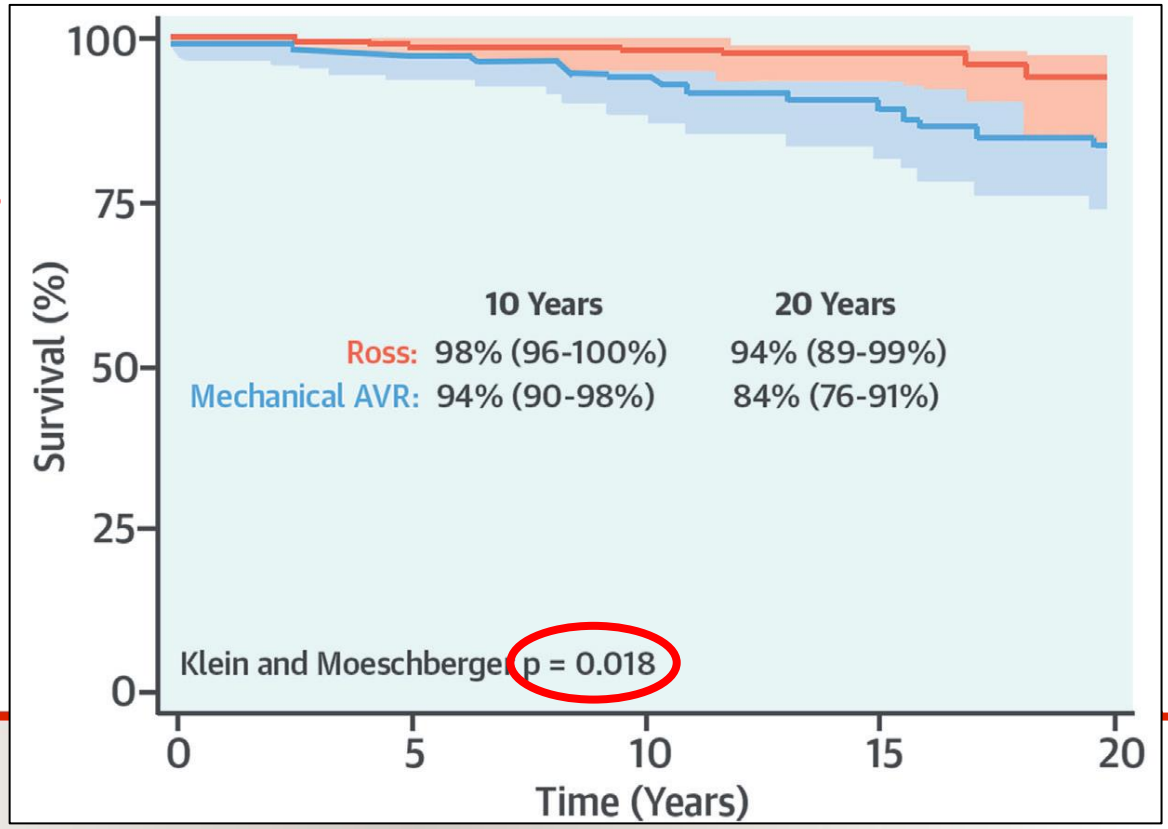
Mazine et al. Circulation 2016

Ross vs. Mechanical AVR

Improved Survival After the Ross Procedure Compared With Mechanical Aortic Valve Replacement

Edward Buratto, MBBS,[a] William Y. Shi, MBBS, PhD,[a] Rochelle Wynne, PhD,[a,b] Chin L. Poh, MBBS,[a,b] Marco Larobina, MBBS,[b] Michael O'Keefe, MBBS,[b] John Goldblatt, MBBS,[b] James Tatoulis, MD,[a,b] Peter D. Skillington, MBBS[a,b]

- 1992-2016
- **392 Ross cases**
- **Propensity-matched: 275 pairs**
- **43 +/- 11 years**



Burratto et al. JACC 2018

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

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

JAMA Cardiology | Original Investigation

Ross Procedure vs Mechanical Aortic Valve Replacement in Adults

A Systematic Review and Meta-analysis

Amine Mazine, MD, MSc; Rodolfo V. Rocha, MD; Ismail El-Hamamsy, MD, PhD; Maral Ouzounian, MD, PhD; Bobby Yanagawa, MD, PhD; Deepak L. Bhatt, MD, MPH; Subodh Verma, MD, PhD; Jan O. Friedrich, MD, DPhil

CONCLUSIONS AND RELEVANCE Data from primarily observational studies suggest that the Ross procedure is associated with lower all-cause mortality compared with mechanical aortic valve replacement. These findings highlight the need for a large, prospective randomized clinical trial comparing long-term outcomes between these 2 interventions.

Mazine et al. JAMA Cardiol 2018

THE ROSS PROCEDURE

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

WHAT ABOUT THE ROSS IN PATIENTS WITH Ao REGURGITATION AND A DILATED ANNULUS?

ACHILLE'S HEEL?

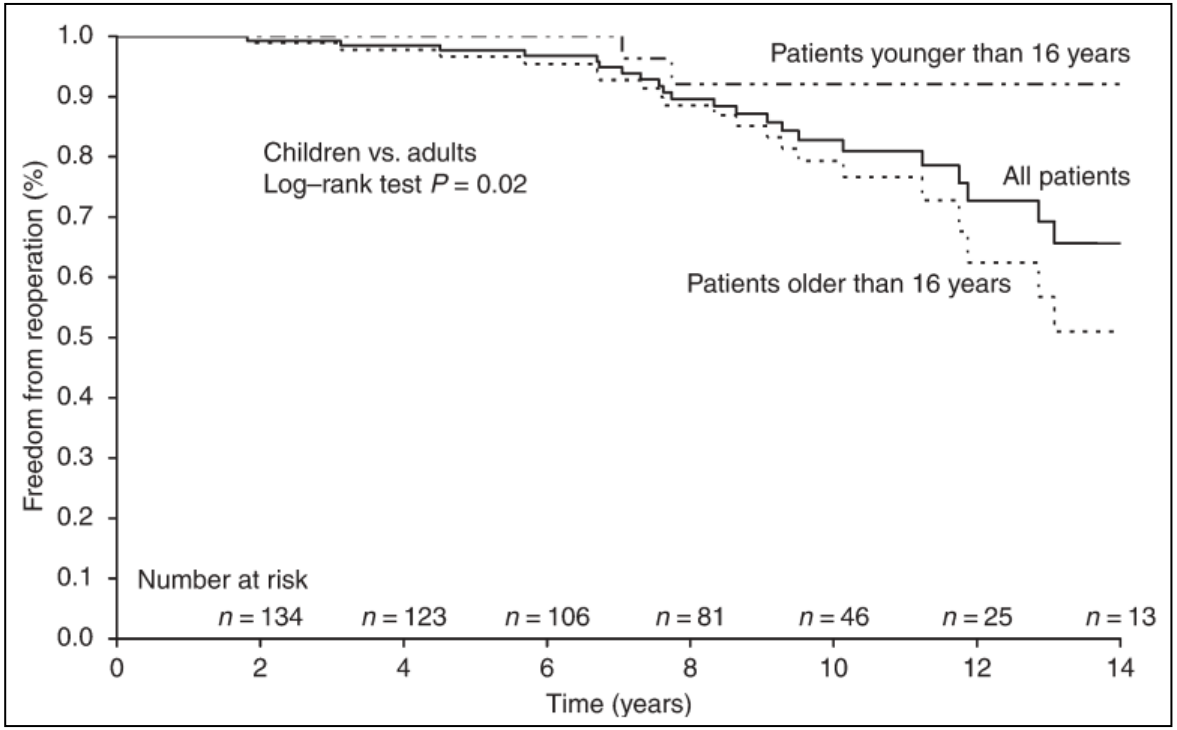
Reoperation

Operative Risk

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

Ross and AI

The Ross procedure in children and young adults: A word of caution

Antonio Laudito, MD[a]
Michael M. Brook, MD[b]
Sam Suleman, BS[a]
Mark S. Bleiweis, MD[a]
Lenardo D. Thompson, MD[a]
Frank L. Hanley, MD[a]
V. Mohan Reddy, MD[a]

TABLE 1. Predictors of autograft failure in univariate Cox proportional hazards models

Predictor	Hazard ratio	95% CI	*P* value
Male	1.39	0.30-6.4	.67
Age (per year)	0.95	0.87-1.04	.30
Prior LVOT surgery	0.83	0.27-2.6	.75
Ross (vs Ross-Konno)	0.74	0.22-2.5	.62
Attempted repair	0.47	0.06-3.7	.47
Sinus obliteration technique	2.6	0.72-9.1	.15
Hemodynamic diagnosis of AI (vs AS)*	4.2	1.14-15.7	.031
AV anulus (per mm)	[illegible]	[illegible]	[illegible]
Stenotic (vs normal)†	0.91	0.11-7.8	.93
Dilated (vs normal)†	0.42	0.10-1.8	.24
PV-AV (per mm)	1.07	0.92-1.23	.37
Crossclamp time (per hour)	0.90	0.39-2.1	.81
Total CPB time (per hour)	0.68	0.36-1.27	.23
Additional procedure	0.79	0.24-2.6	.70
Absolute PV anulus	1.01	0.80-1.27	.96
Absolute PV-AV anulus	1.7	0.33-9.3	.52

Ross and AI

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

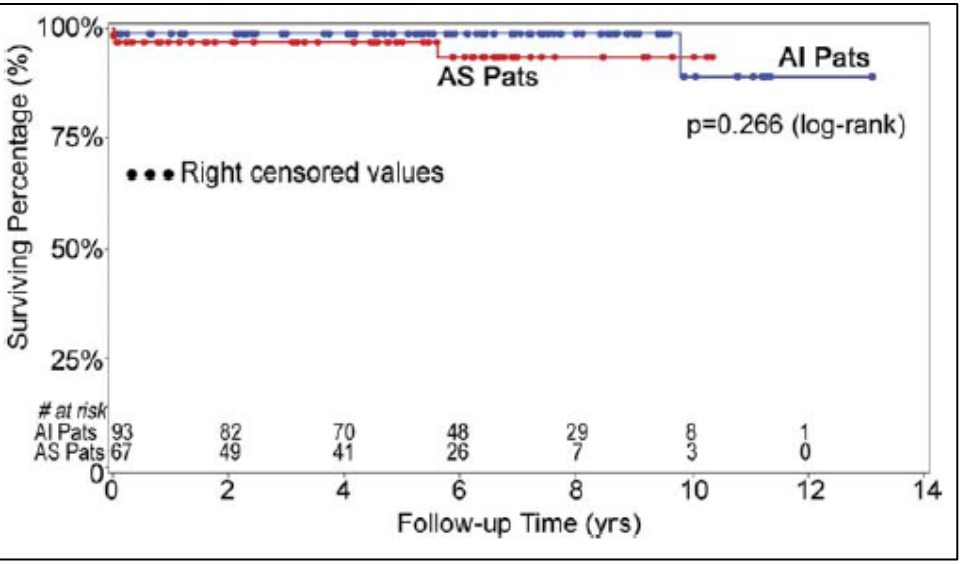
TABLE 2. Freedom from reoperation on the pulmonary autograft

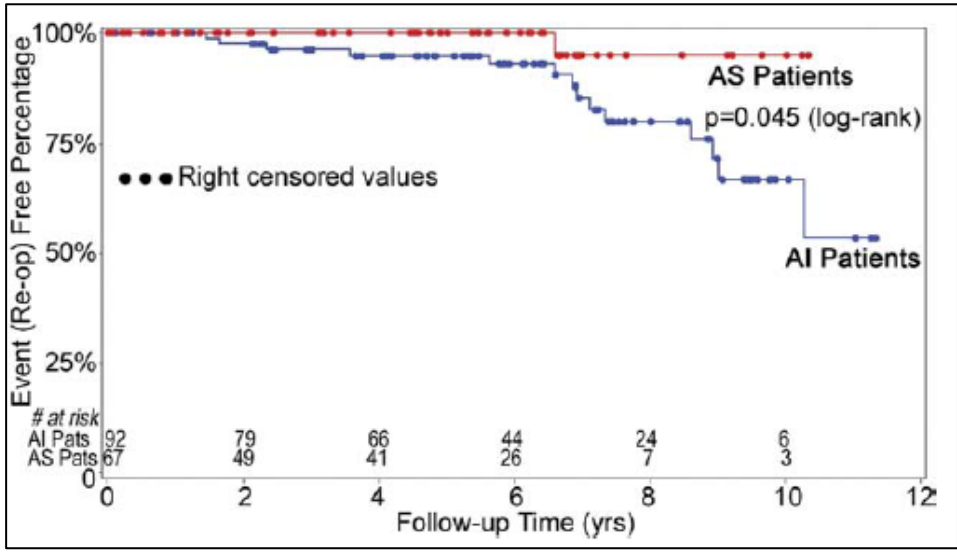
	5 y	10 y	15 y	*P* value
Operative technique				
Subcoronary/inclusion	96.3 ± 1.8 (98)	92.1 ± 3.3 (34)	92.1 ± 3.3 (10)	
Root replacement	96.9 ± 1.7 (86)	94.1 ± 2.5 (62)	92.4 ± 3.0 (4)	.82
Aortic/pulmonary annulus				
No mismatch	98.2 ± 1.2 (98)	98.2 ± 1.2 (44)	98.2 ± 1.2 (6)	
Mismatch	94.6 ± 2.3 (85)	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

Ross and 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





ROSS PROCEDURE

Ross Procedure at the Crossroads

Tirone E. David, MD

valve failure in these patients. At present, I no longer recommend the Ross procedure in patients with AI and dilated aortic annulus. In our practice, most of these patients have a congenital bicuspid aortic valve.

David TE. Circulation 2009

PARADIGM CHANGE

~~ANTICOAGULATION VS. REOPERATION~~

SURVIVAL + QUALITY OF LIFE

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 (%)
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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

HOW I TEACH IT

The Ross Procedure: How I Teach It

Check for updates

Amine Mazine, MD, MSc,* Aly Ghoneim, MD,* and Ismail El-Hamamsy, MD, PhD

Division of Cardiac Surgery, Montreal Heart Institute, Université de Montréal, Montreal, Quebec, Canada

Ann Thorac Surg 2018

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

MULTIMEDIA MANUAL OF CARDIO-THORACIC SURGERY

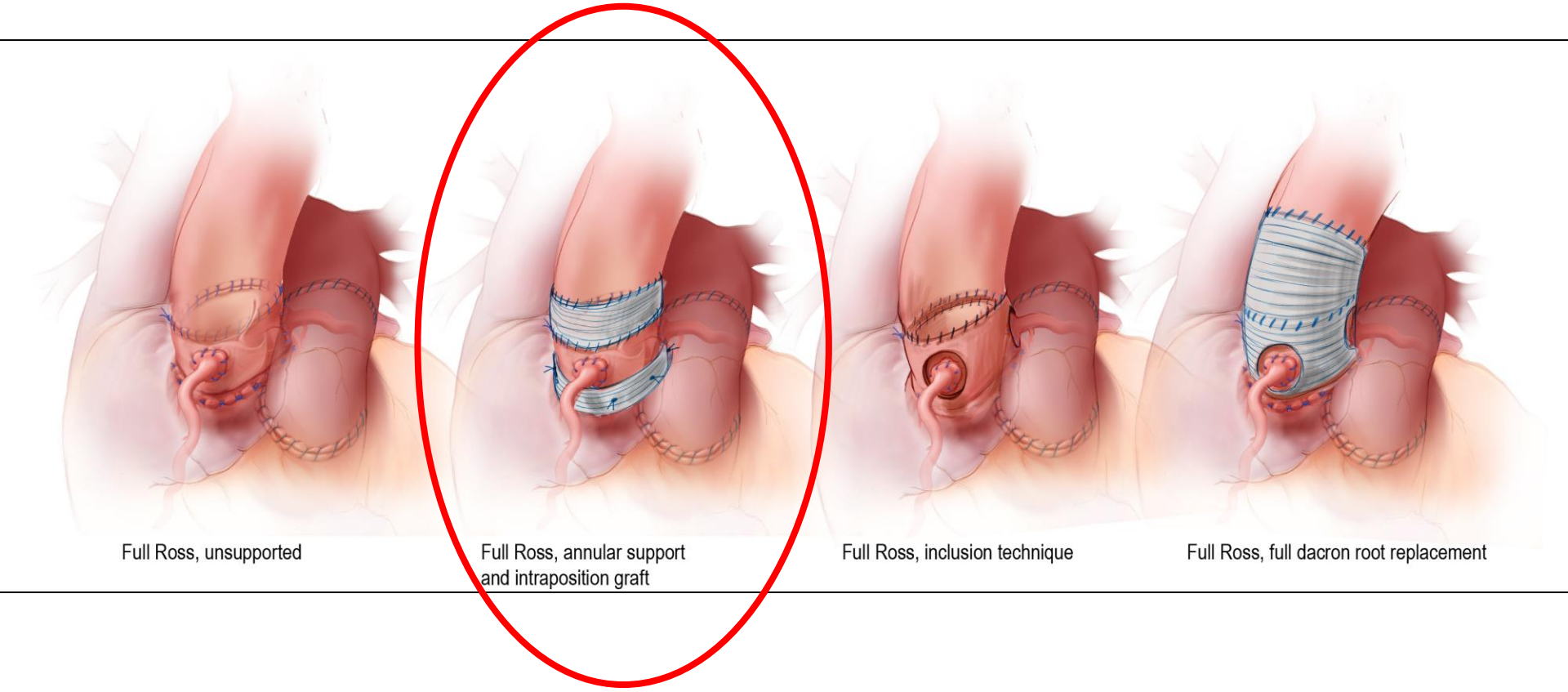
The Ross procedure: total root technique

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

MMCTS 2014

Tailored Approaches to AI

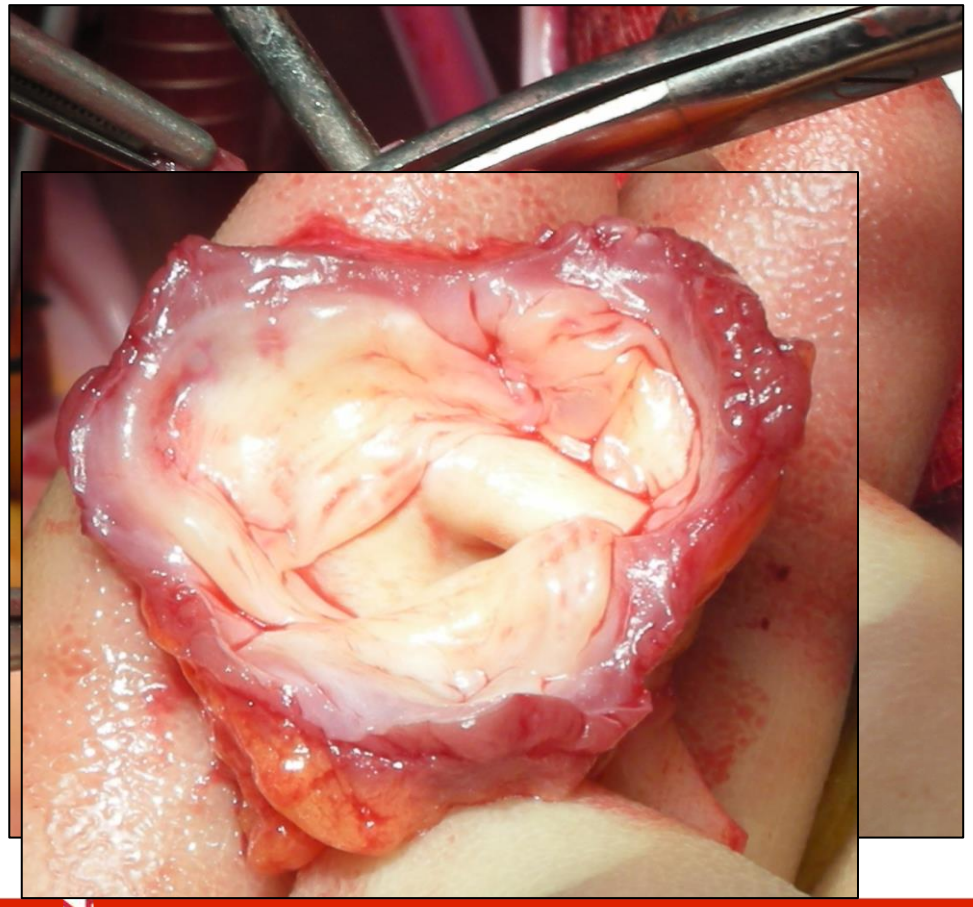


Mazine, El-Hamamsy et al. JACC 2018 (in press)

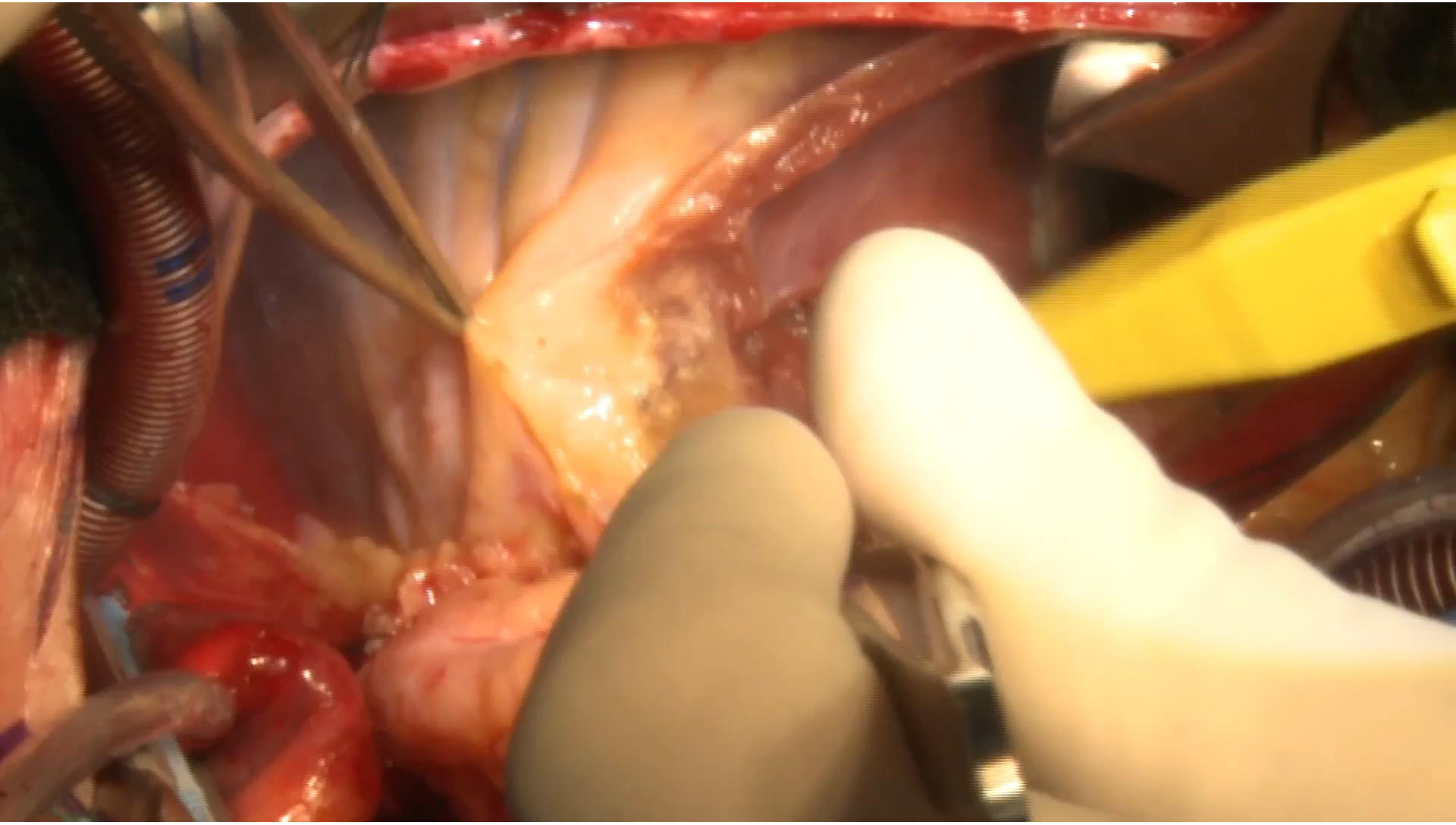
Tailored Ross Technique

- Trimming of infudibular muscle below the valve

- Scalloping



Pulmonary Autograft Trimming

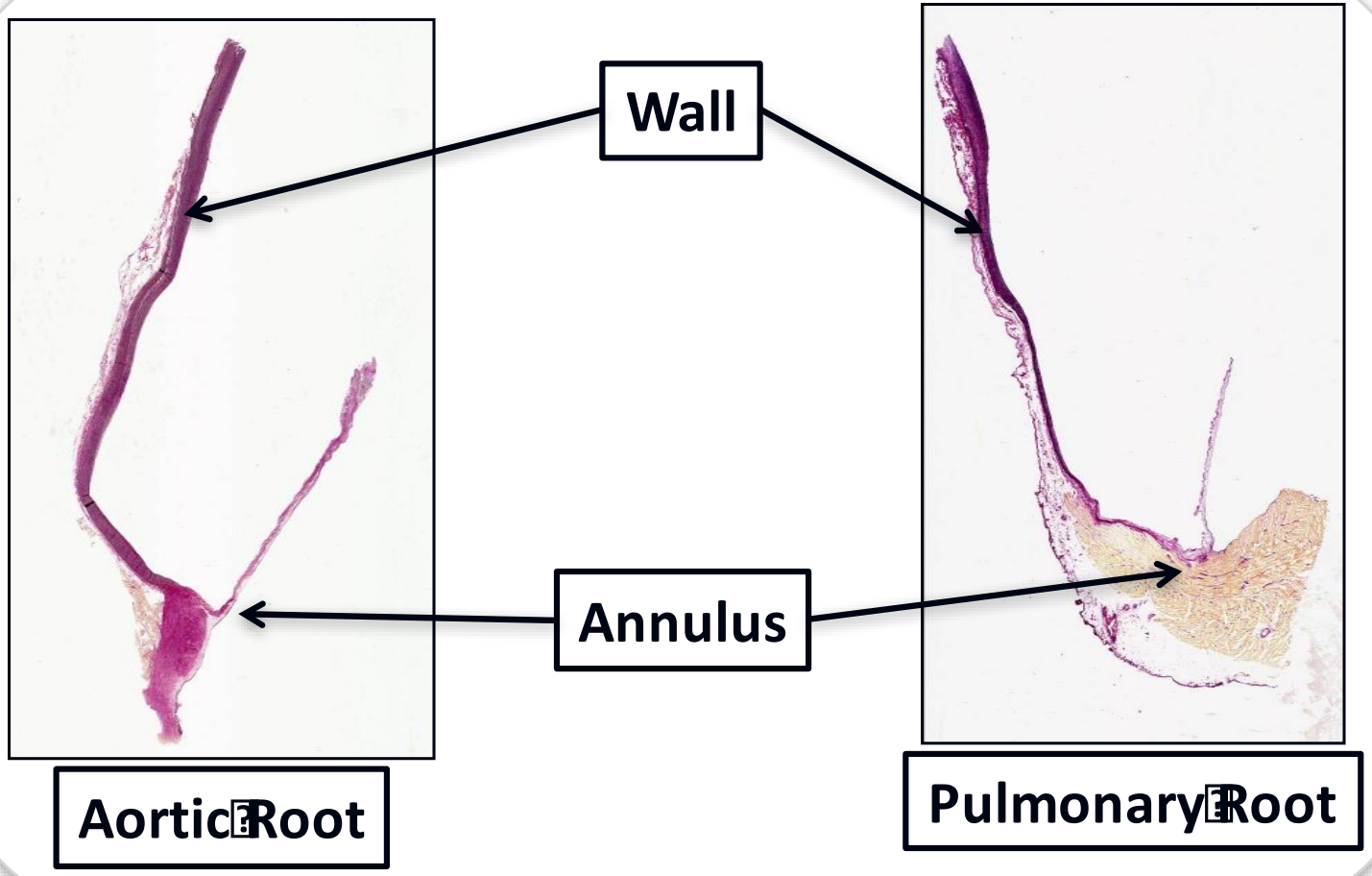


Tailored Ross Technique

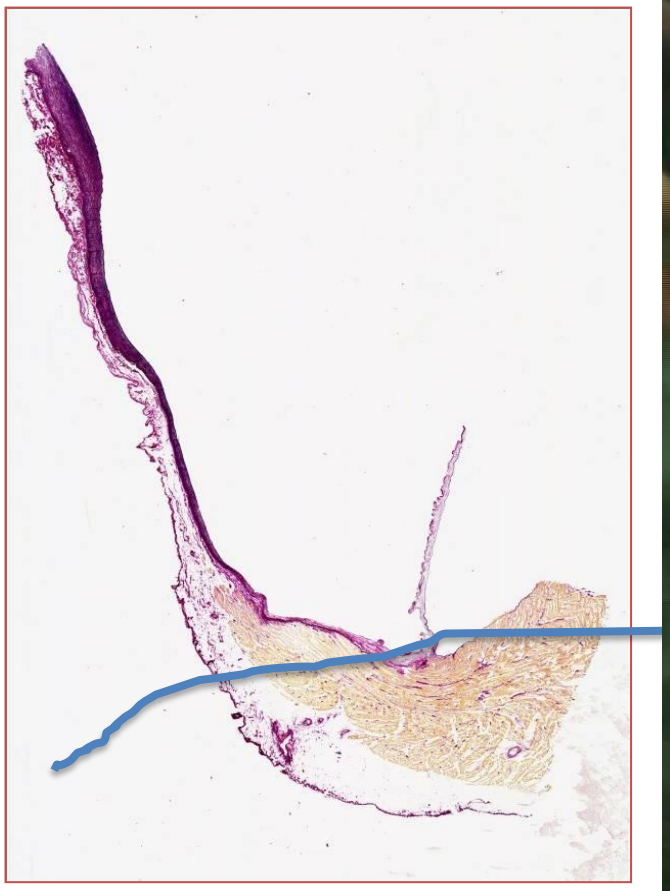
Proximal suture line

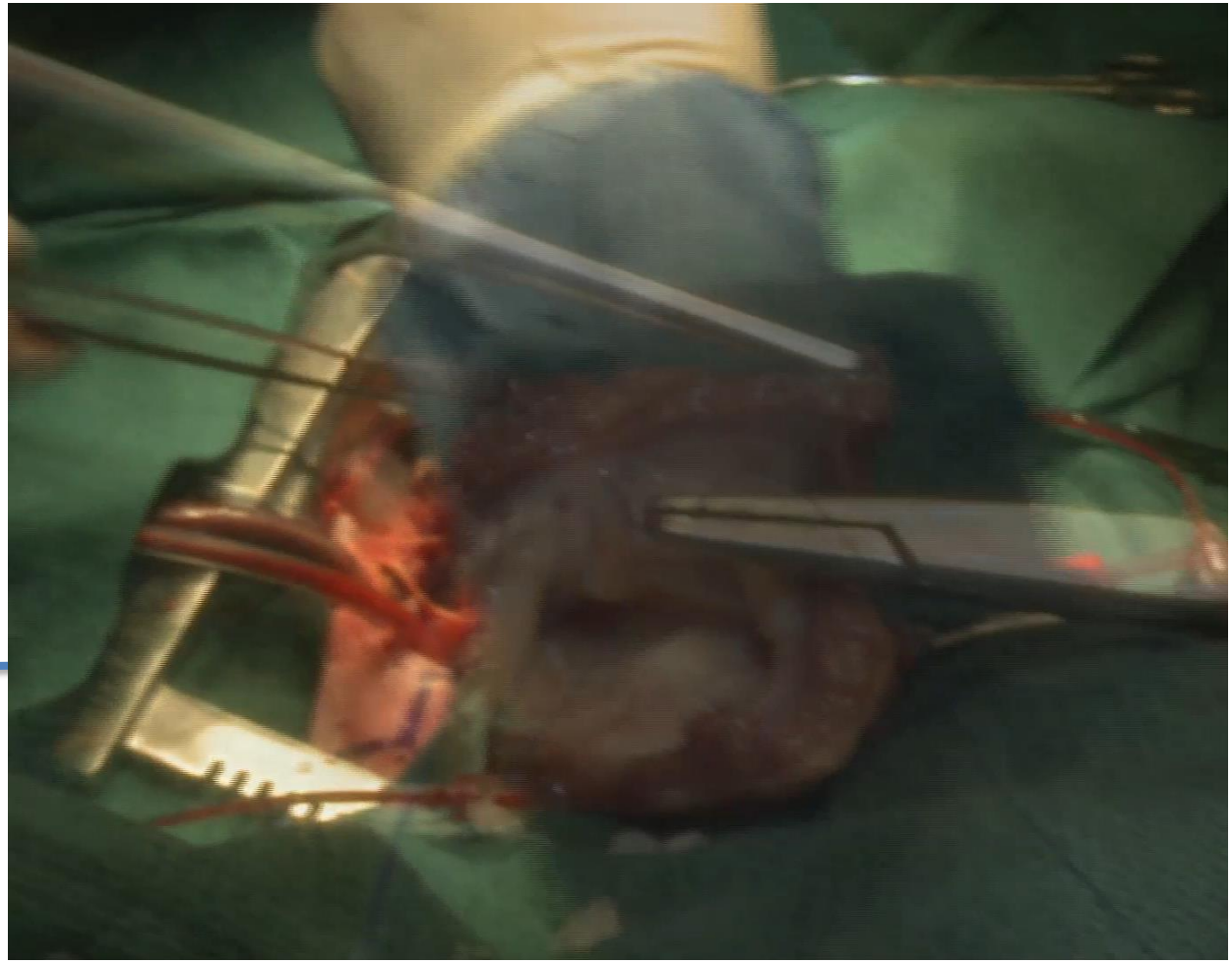
- Place the autograft in an infra-annular position (inside the LVOT)
- Interrupted sutures
- Commissural Symmetry

Aortic vs Pulmonary Anatomy



Tailored Ross Technique

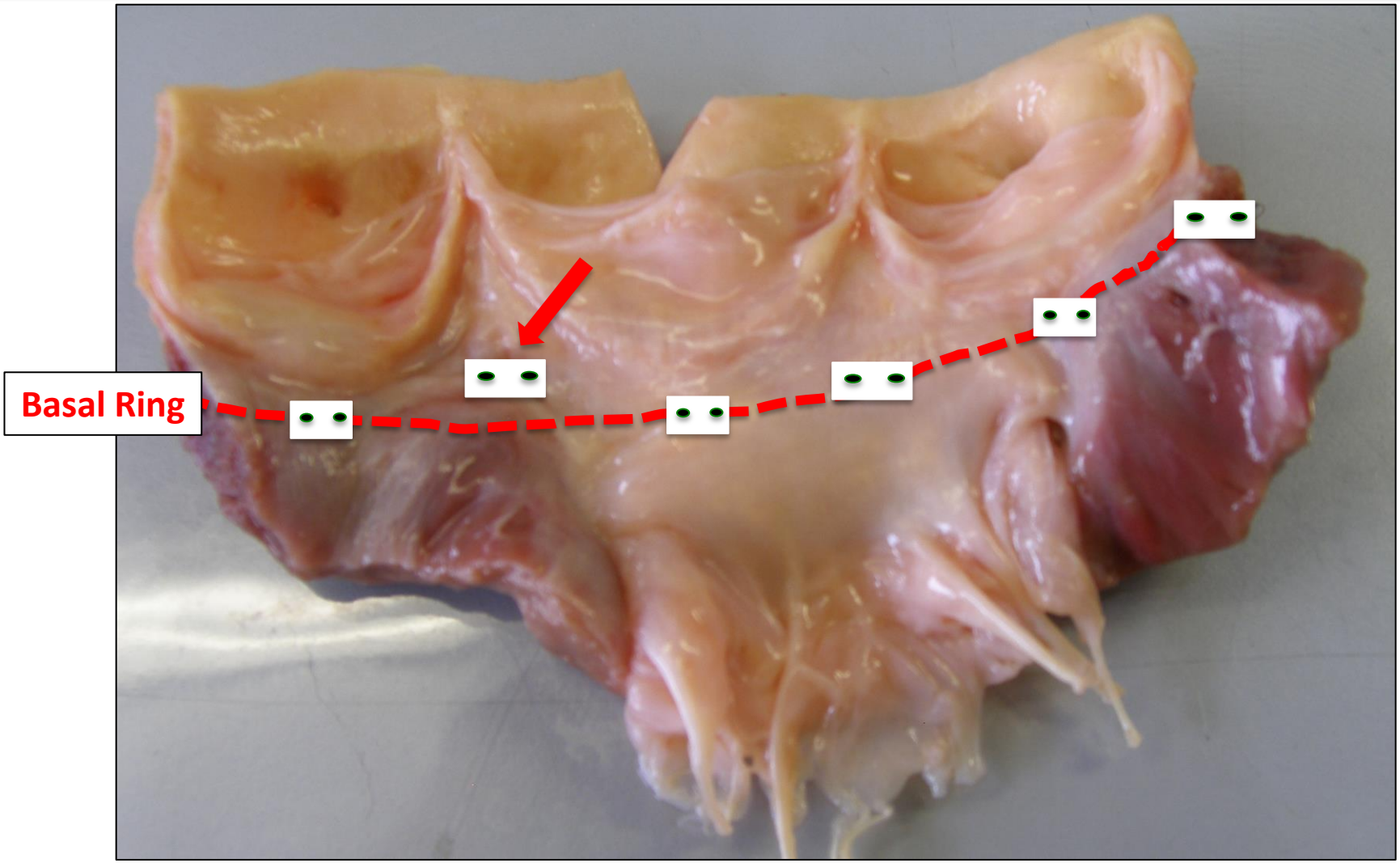




Extra-Aortic Annuloplasty

- Extra-aortic ring annuloplasty is used if:
  - **AI or mixed AS/AI (with predominant AI) is the indication**
  - **Annulus mismatch >2mm (Aortic > Pulmonary)**

Extra-Aortic Annuloplasty



Early results of extra-aortic annuloplasty ring implantation on aortic annular dimensions

Lauren Basmadjian, MD,[a] Arsène J. Basmadjian, MD, MSc,[b] Louis-Mathieu Stevens, MD, PhD,[c] François-Pierre Mongeon, MD,[b] Raymond Cartier, MD,[a] Nancy Poirier, MD,[a] and Ismail El Hamamsy, MD, PhD[a]

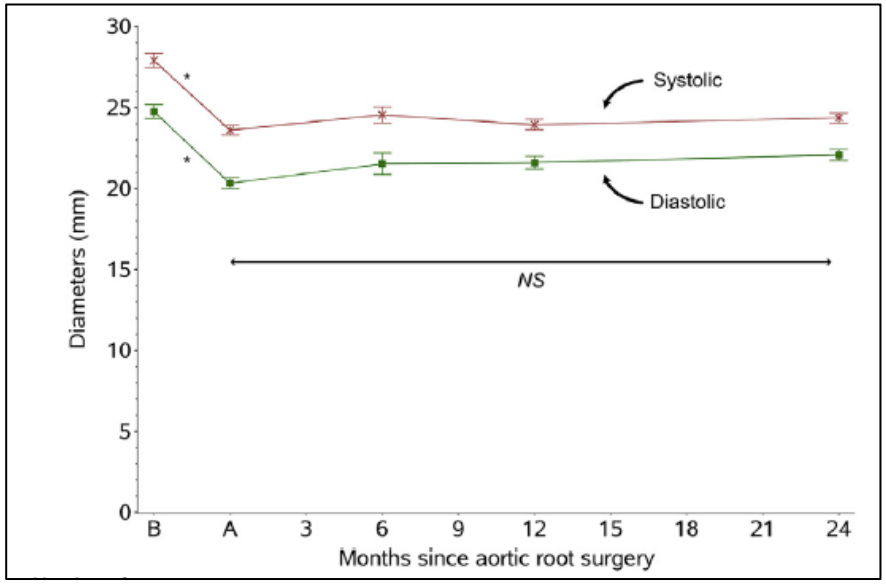
JTCVS 2017

Reimplantation versus remodelling with ring annuloplasty: comparison of mid-term outcomes after valve-sparing aortic root replacement†

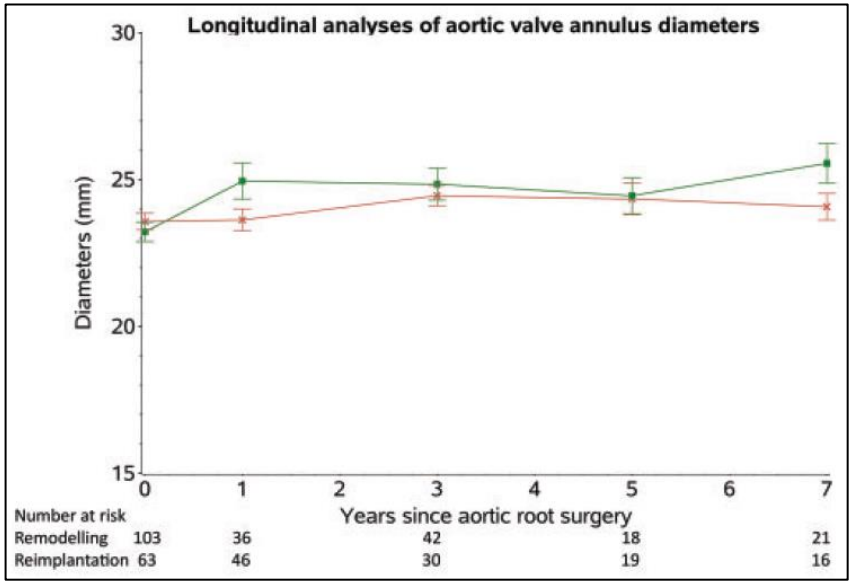
Marien Lenoir[a], Bart Maesen[b], Louis-Mathieu Stevens[c], Raymond Cartier[a], Philippe Demers[a], Nancy Poirier[a], Michaël Tousch[a] and Ismail El-Hamamsy[a,*]

EJCTS 2018

Annular reduction and Stabilization

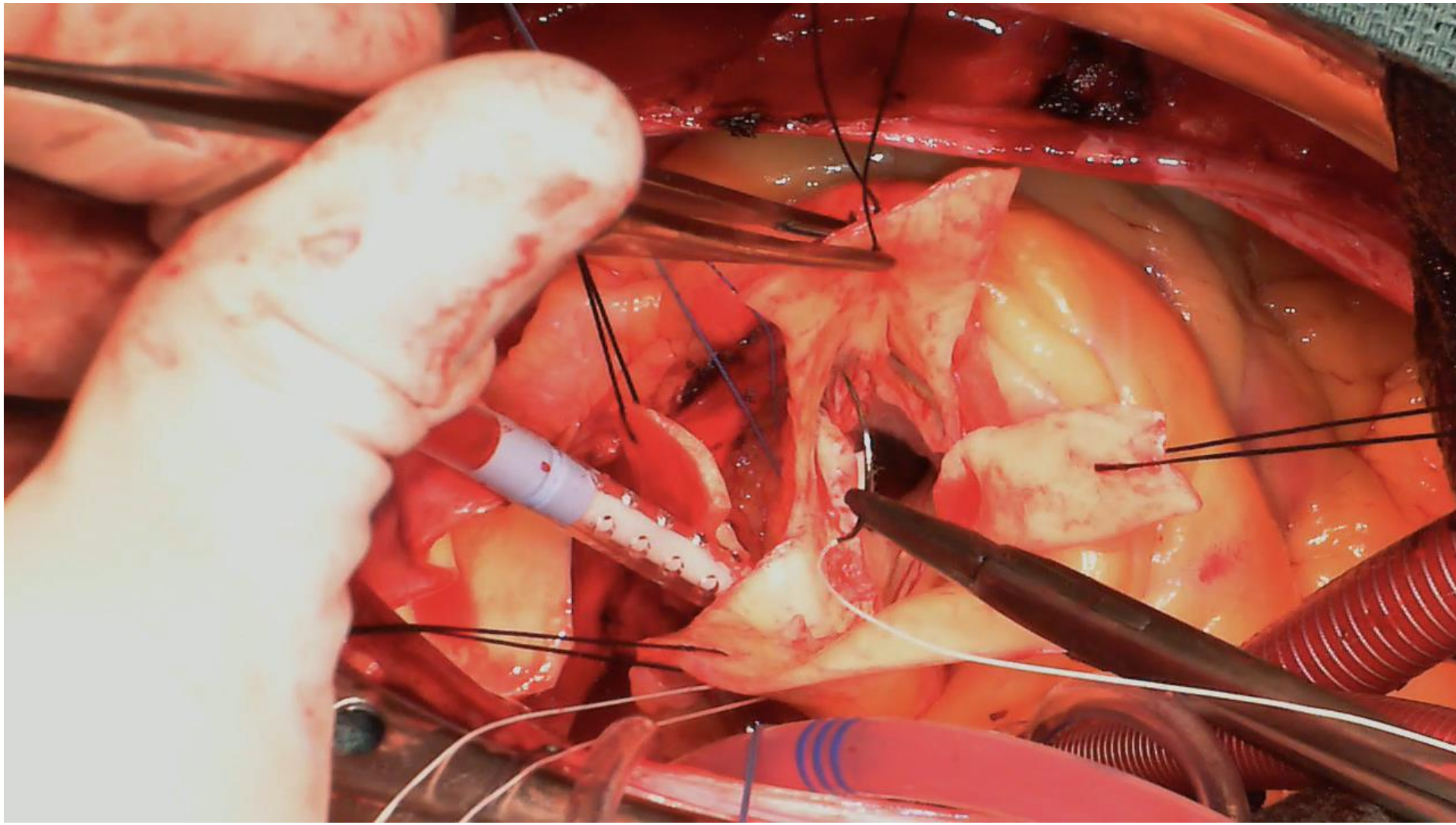


Basmadjian et al. JTCVS 2017

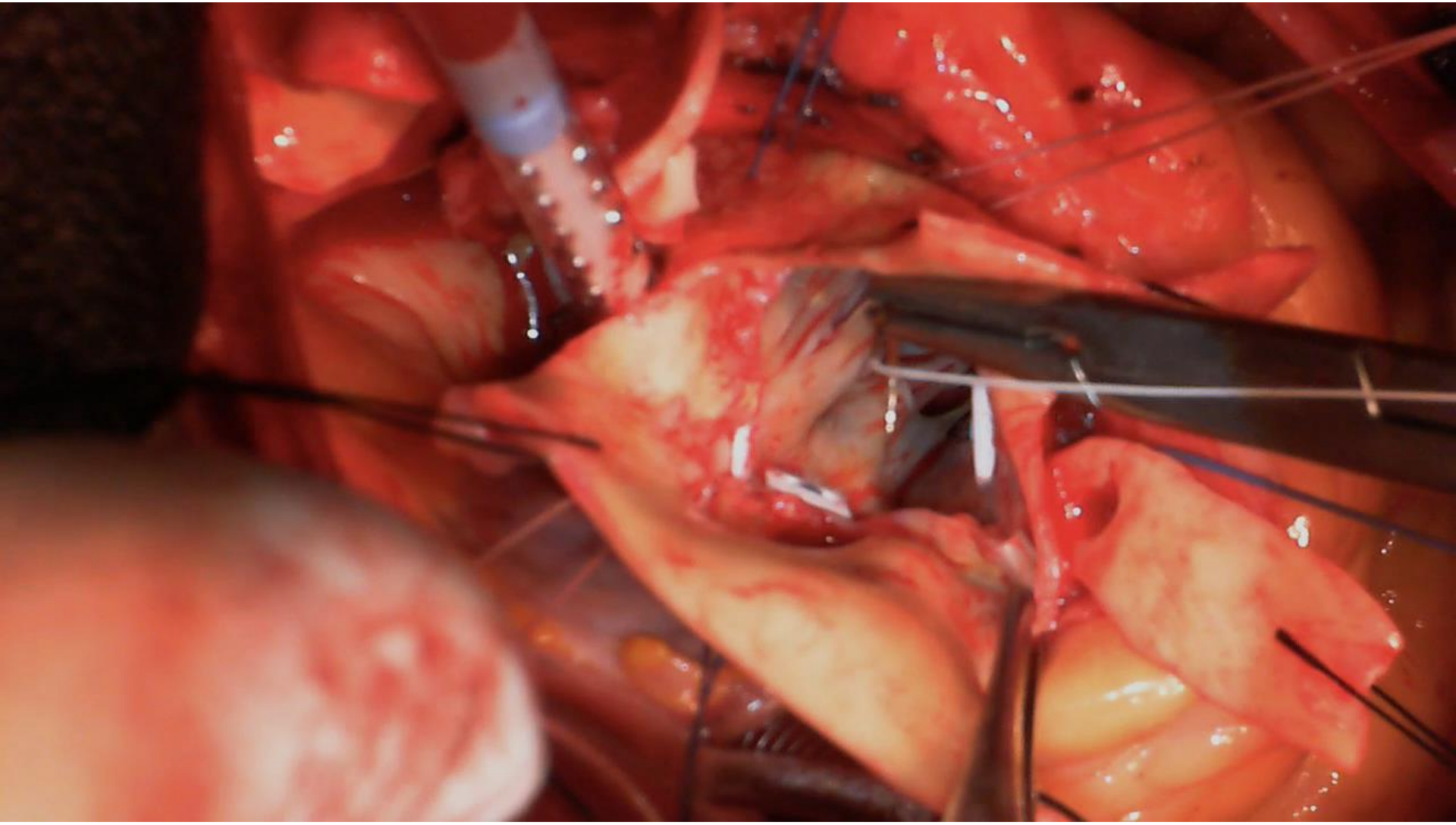


Lenoir et al. EJCTS 2018 (in press)

Aortic Annuloplasty

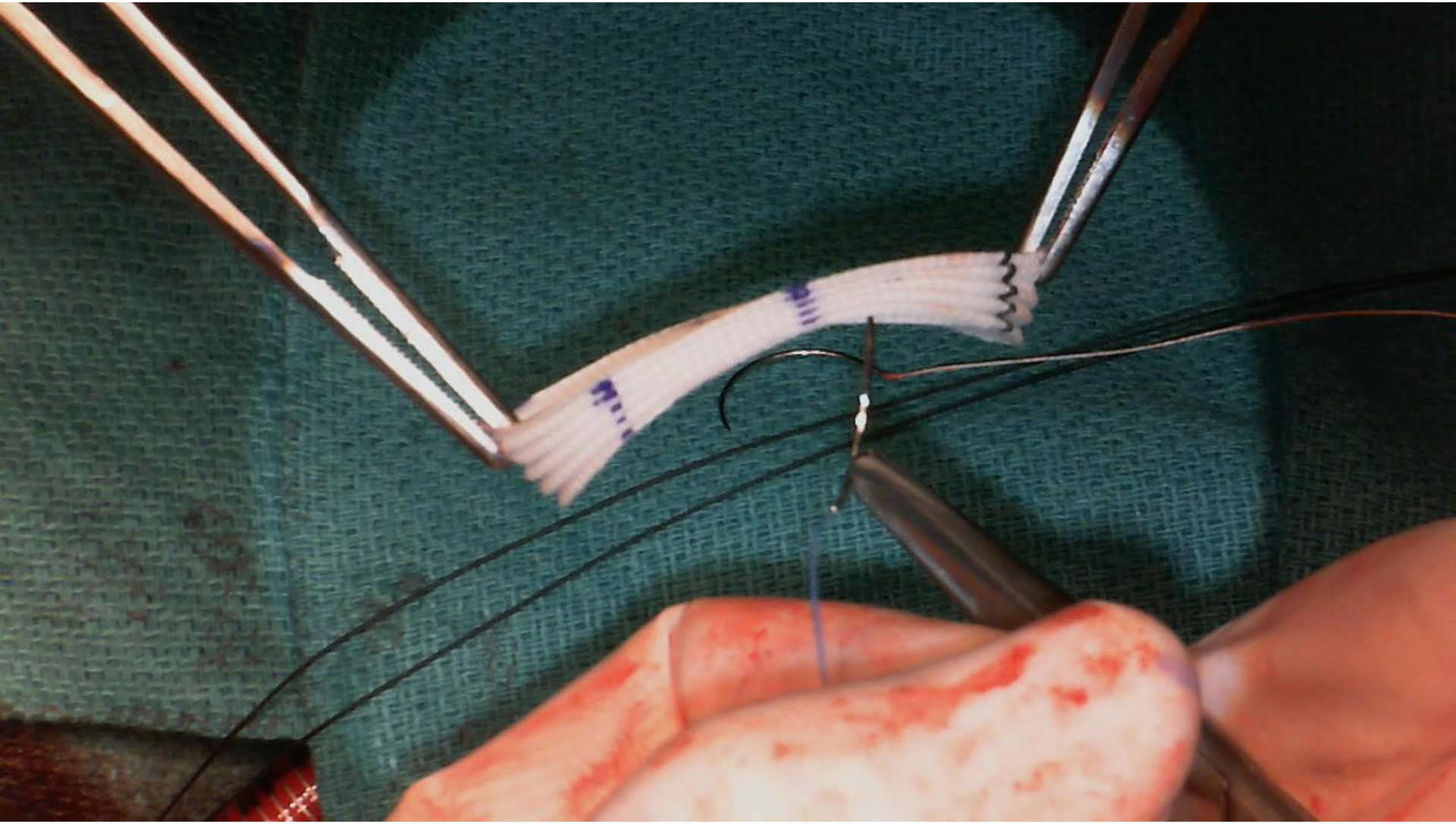


Aortic Annuloplasty



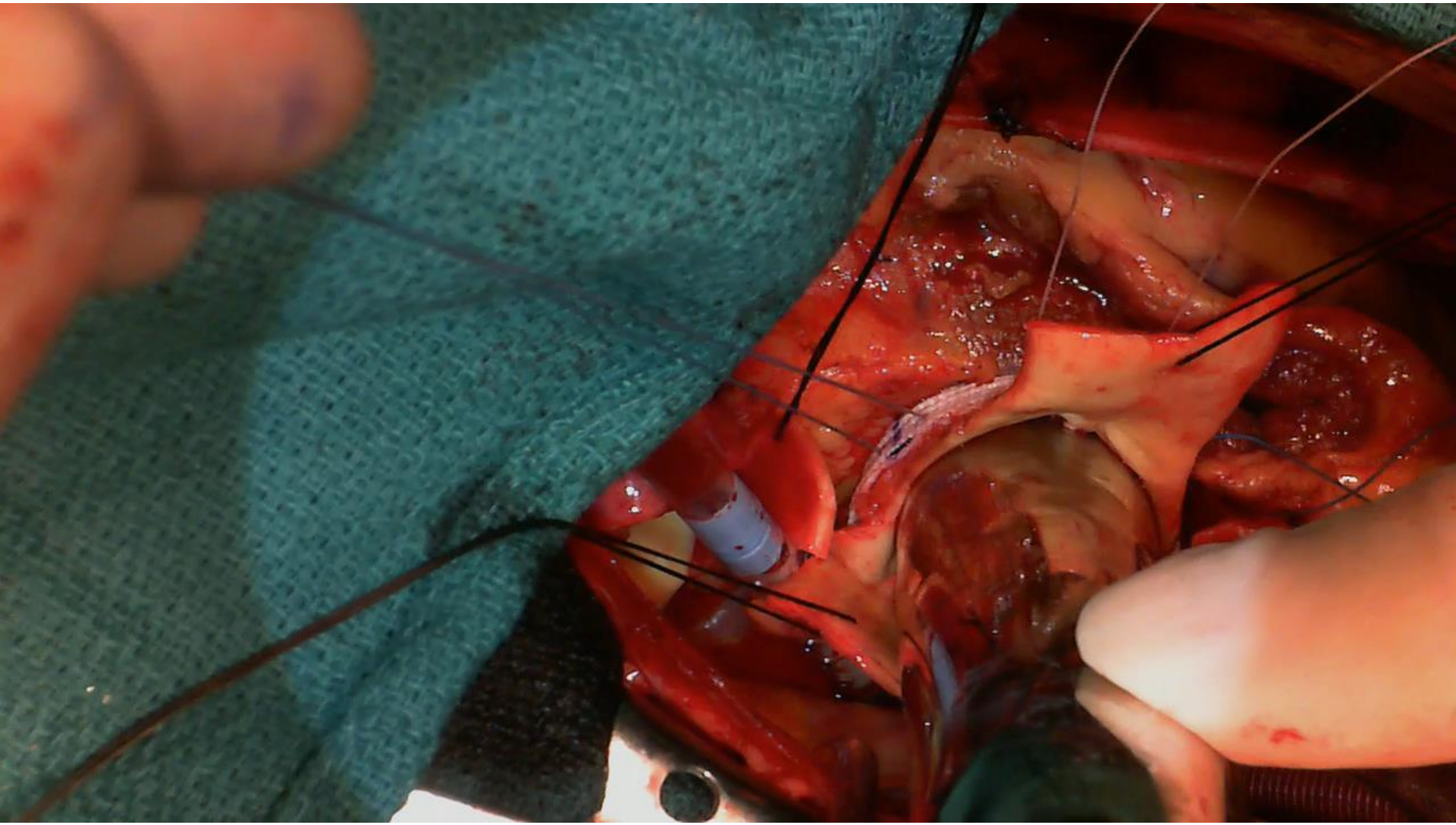
Aortic Annuloplasty

Aortic Annuloplasty

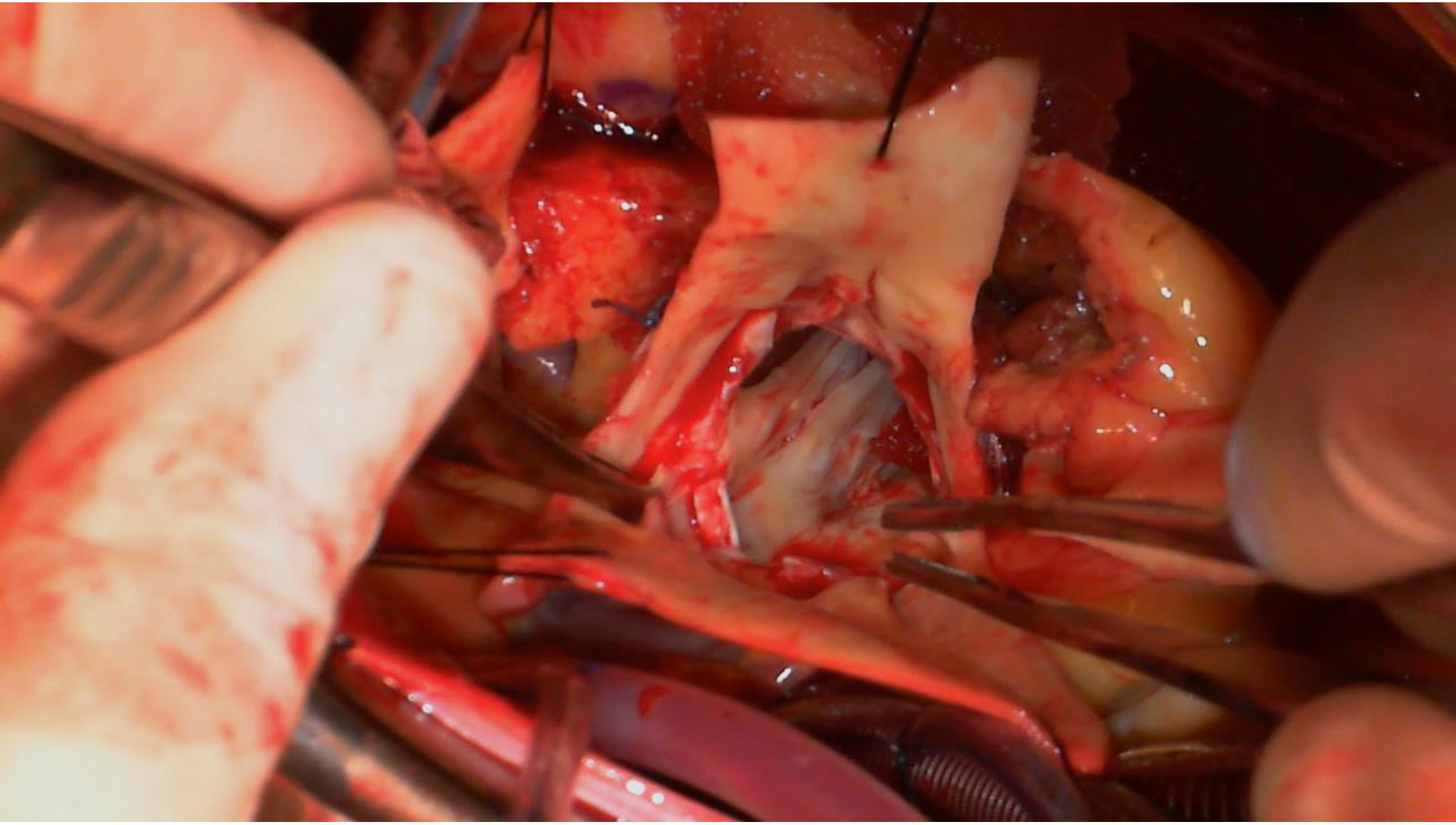


Aortic Annuloplasty

Aortic Annuloplasty



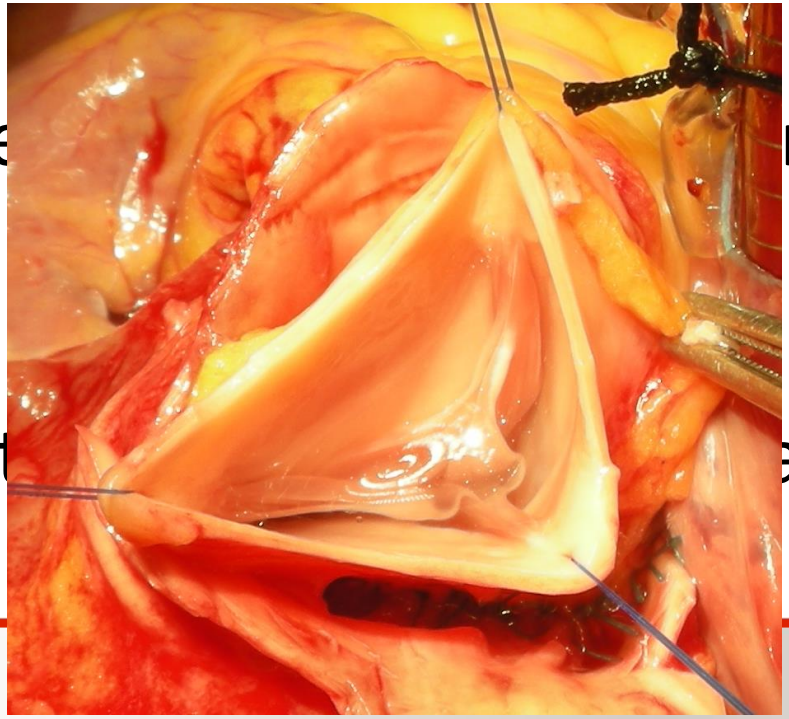
Aortic Annuloplasty



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



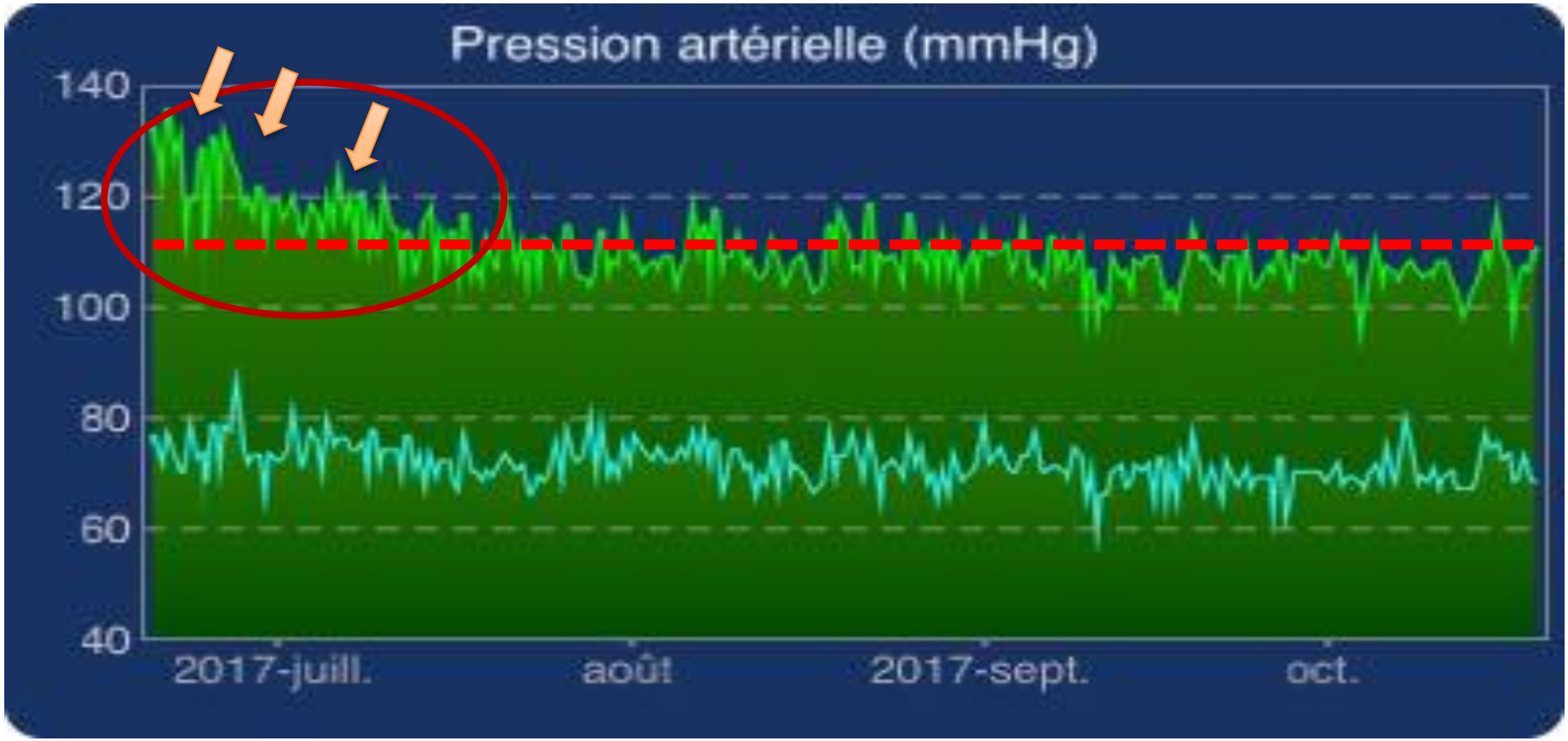
Tailored Ross Technique

Postoperative Management

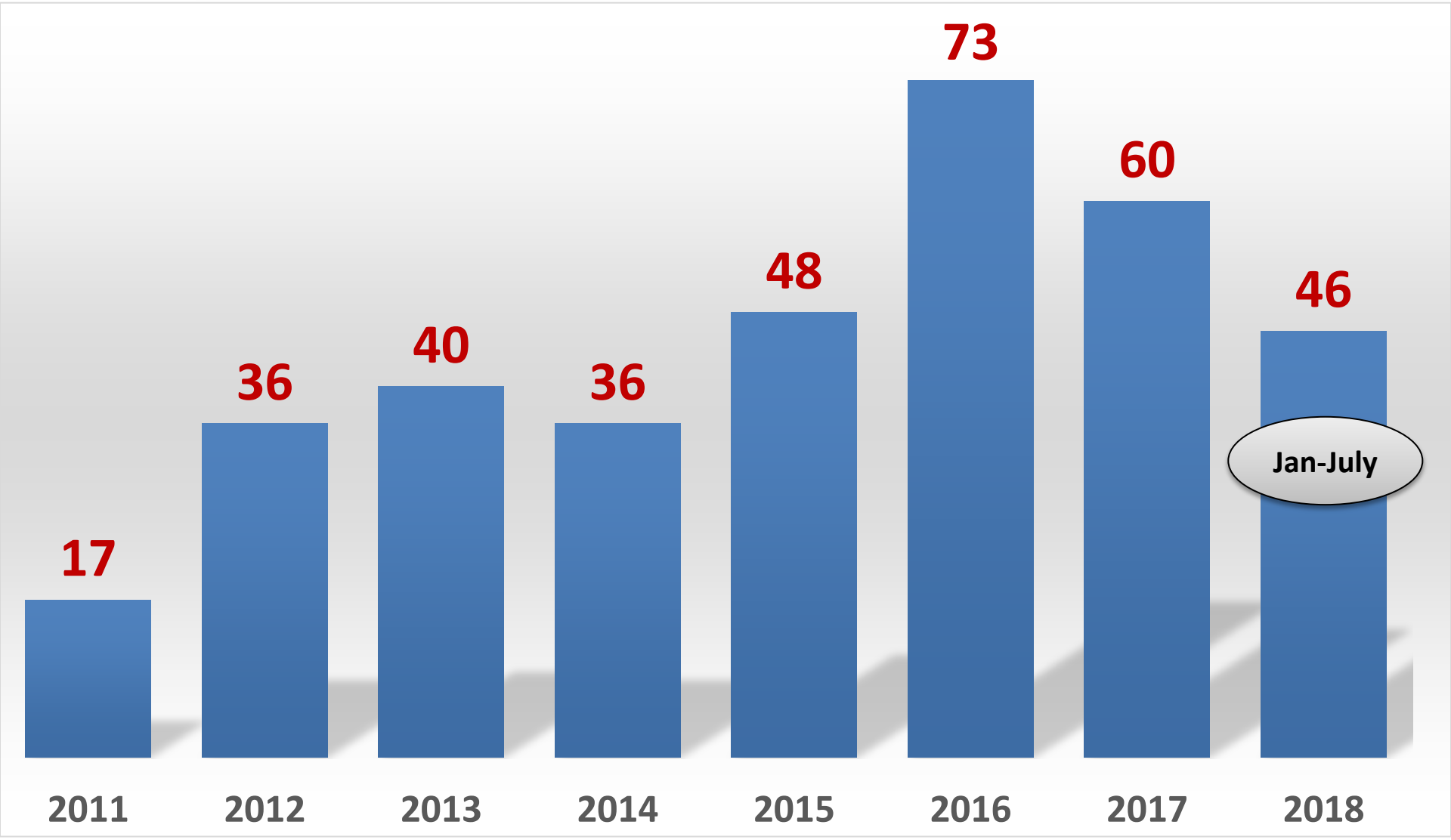
- Strict BP control in the perioperative period (max sBP 100-110mmHg)
- Home BP monitoring 6 months (max sBP 100-110mmHg)

BP Remote Monitoring

Ross Procedure June 2017



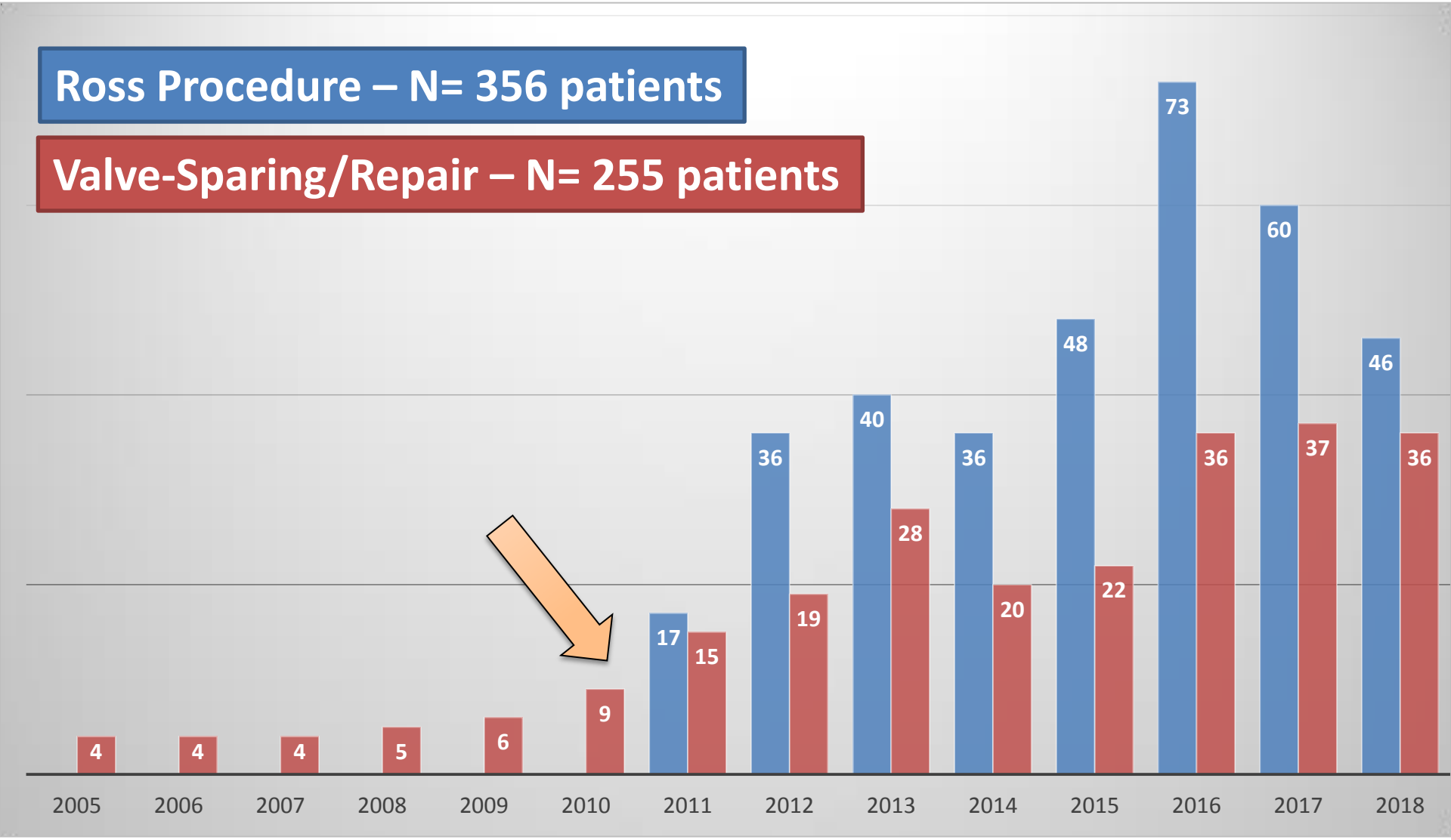
Montreal Ross Program (N=356 patients)



INSTITUT DE CARDIOLOGIE DE MONTRÉAL

AFFILIÉ À Université de Montréal

Montreal Aortic Program (N=611 patients)



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MONTREAL HEART INSTITUTE (N=356)

2011-2018

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

- 15% redos (N=53)
- 60% concomittant procedures (N=208)
- 5% active endocarditis (N=17)

Operative mortality: 0.6% (n=2)

MONTREAL HEART INSTITUTE (N=356)

- **The first 100 patients**
  - Temporary dialysis (n=5)
  - Reexploration for bleeding (n=4)
  - Mortality (n=2)

- **The last 256 patients**
  - Temporary dialysis (n=3): **1.2%**
  - Reexploration for bleeding (n=2): **<1%**
  - **Mortality (n=0): 0%**

Montreal Ross Program

2011 – 2018 : 281 consecutive Ross procedures with ≥ 1 year of follow-up
(Mean age : 46 ± 7 years)

Exclusions:
- Endocarditis (n=18)
- Previous AVR (n=22)

241 Ross procedures

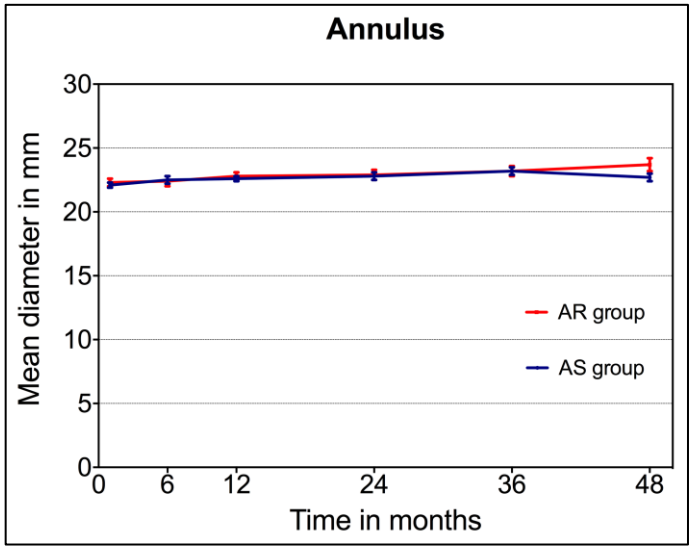
AR group (n=73)

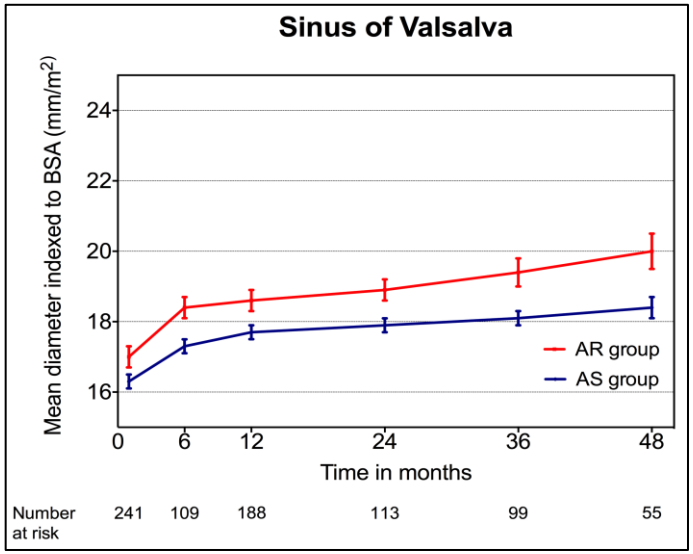
AS group (n=168)

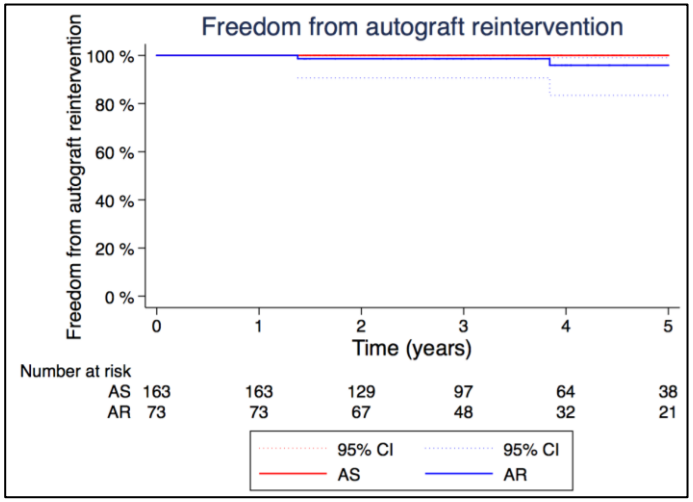
Mean Follow-up: 29 ± 11 months

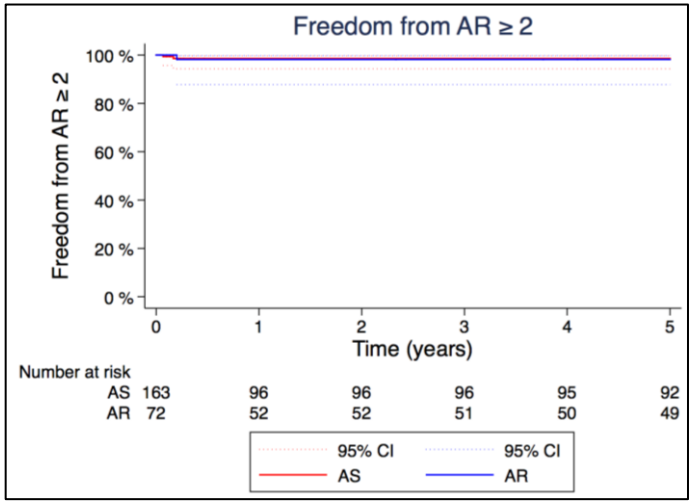
100% complete for yearly clinical and echo follow-up

Ross Procedure with Ring Annuloplasty









Bouhout,…,El-Hamamsy. EACTS 2018

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

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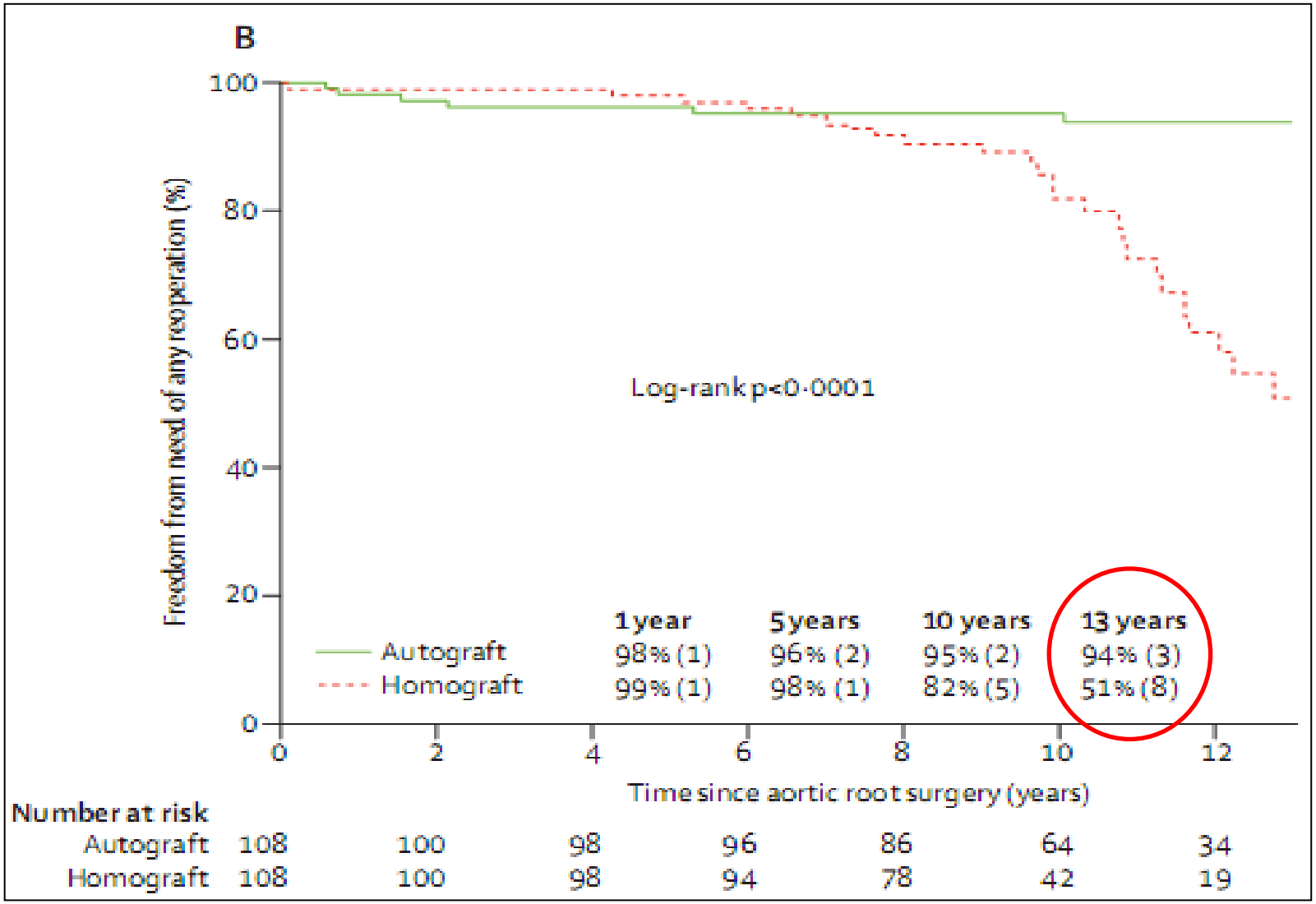
ANY Reoperation



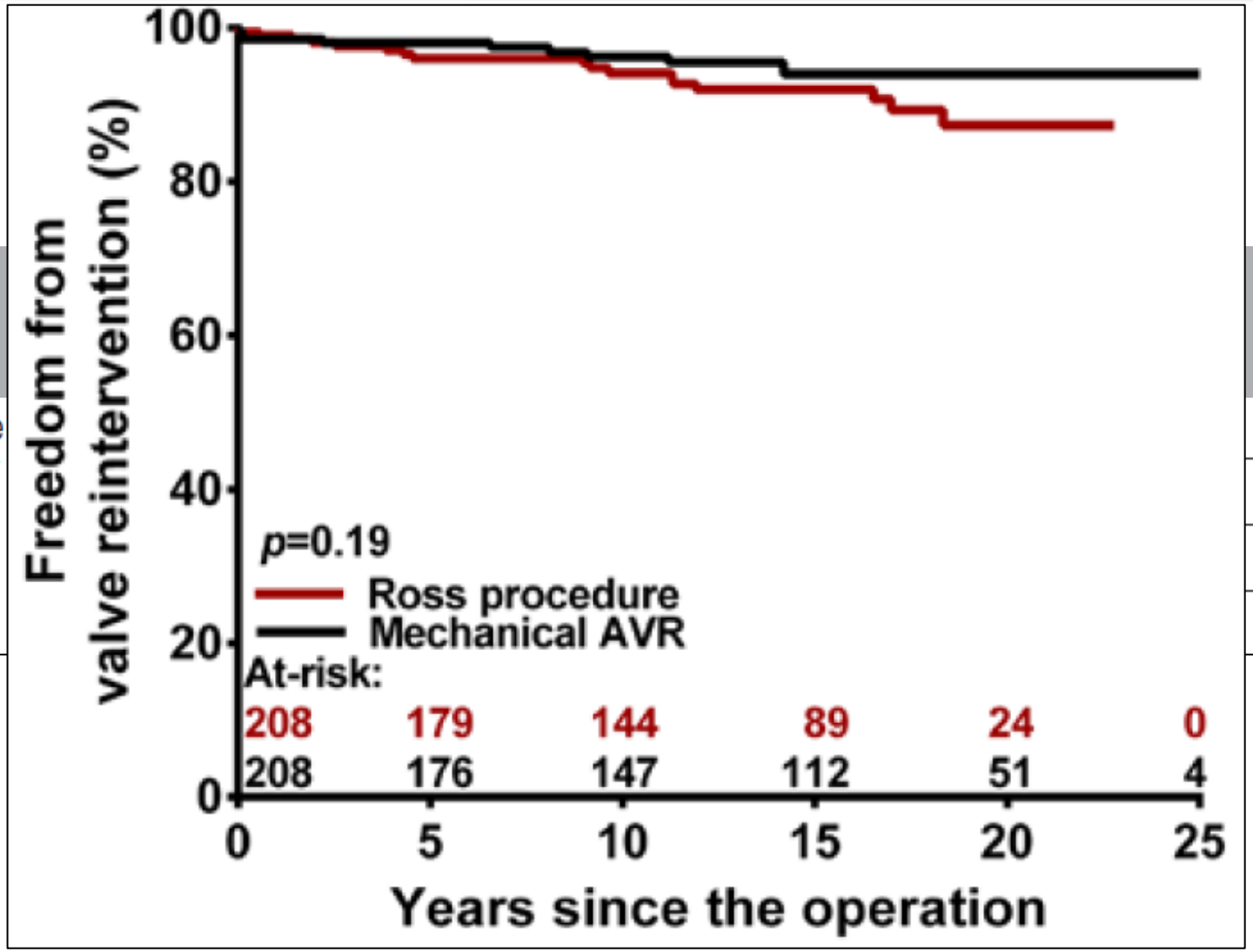
El-Hamamsy et al. Lancet 2010

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

AFFILIÉ À Université de Montréal

Ross Reoperation (aortic/pulmonary)

End Point	*P* Value
Operated valve reintervention*	0.18



Mazine et al. Circulation 2016

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

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%
Mastrobuoni et al. (2015)	Single center	1991-2014	306	10.6*	42	58.5%	31% 0%	2.3%	NA	NA	(AS 83%) (AI 65%)
Skillington et al. (2013)	Single center	1992-2012	310	9.4	39.3	92%	46% 32% 22%	0.3%	97%	94%	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%

1%/patient-year reoperation range

Ann Transl Med, August 2017

The Ross procedure: time for a hard look at current practices and a reexamination of the guidelines

Ismail El-Hamamsy, Ismail Bouhout

JTCVS, September 2017

The Ross procedure is the best operation to treat aortic stenosis in young and middle-aged adults

Maral Ouzounian, MD, PhD, Amine Mazine, MD, MSc, and Tirone E. David, MD

JACC, March 2018

Is it Time to Reconsider Use of the Ross Procedure for Adults?*

Gösta B. Pettersson, MD, PHD,[a] Eugene H. Blackstone, MD[a,b]

JTCVS, September 2018

The Ross procedure: Time to reevaluate the guidelines

Martin Misfeld, MD, PhD, and Michael A. Borger, MD, PhD

PARADIGM CHANGE

~~ANTICOAGULATION VS. REOPERATION~~

SURVIVAL + QUALITY OF LIFE

SIMILAR
OPERATIVE RISK

RESTORED
LATE SURVIVAL

EXCELLENT
QUALITY OF LIFE

BETTER
HEMODYNAMICS

BETTER FREEDOM FROM
VALVE-RELATED COMPLICATIONS

ICM-01-01-2012-08

CONCLUSION

- **YOUNG ADULTS** = The choice of prosthesis has a direct impact on long-term prognosis
- **CONVENTIONAL AVR IN THE YOUNG** = Excess long-term mortality versus general population
- **ROSS PROCEDURE** = Improved long-term survival and quality of life in selected patients
- **IN PATIENTS WITH NON-REPAIRABLE AI,** a tailored Ross procedure = Improved durability

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