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Optimal Strategy for Aortic Root Replacement: Ross

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The Society
of Thoracic
Surgeons



EACTS
European Association For Cardio-Thoracic Surgery



Conflict of Interest Disclosure

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Director of Homograft Tissue Bank

Optimal Strategy for Aortic Root Replacement

Gold Standard

Thorax (1968), 23, 338.

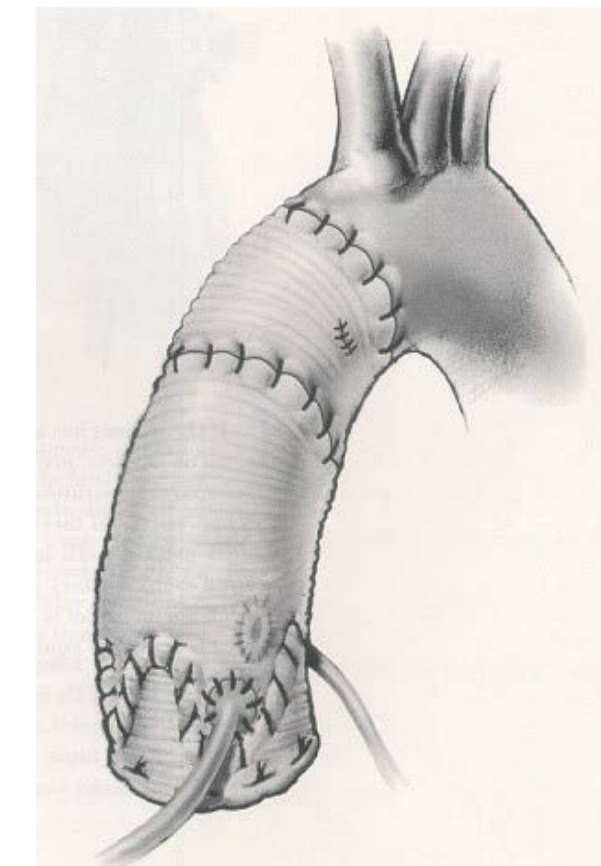
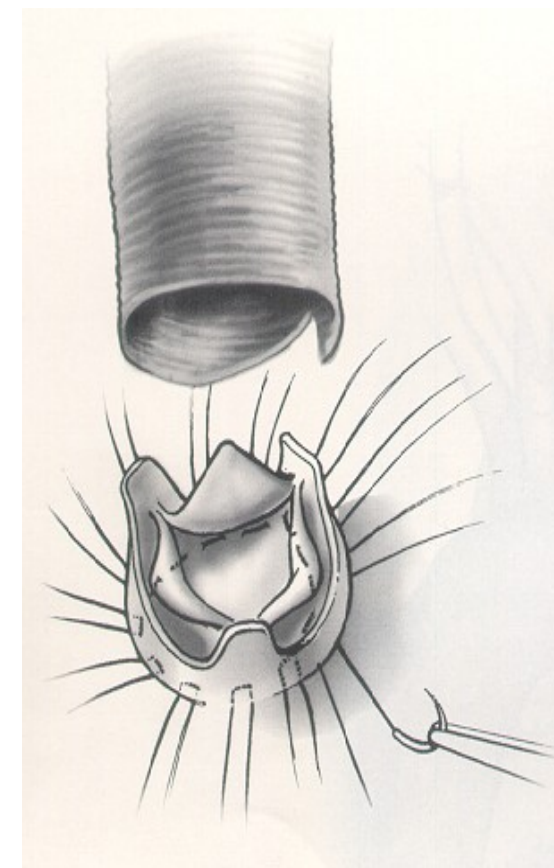
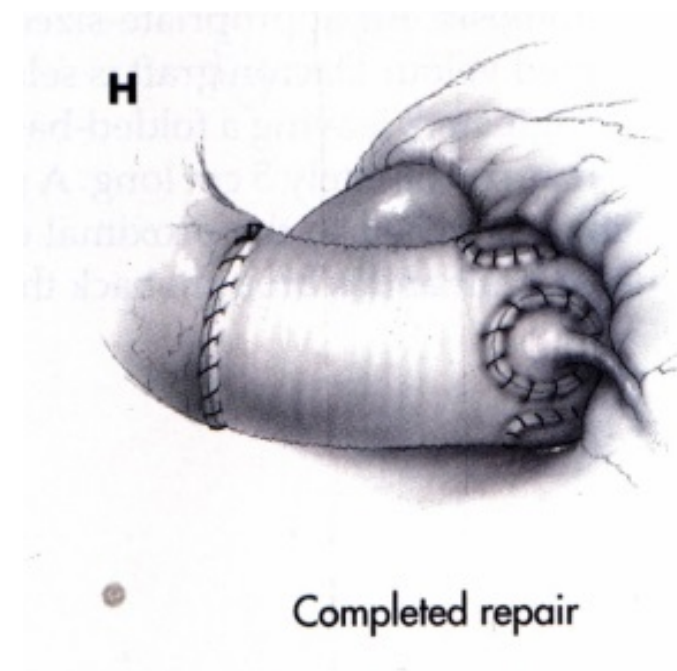
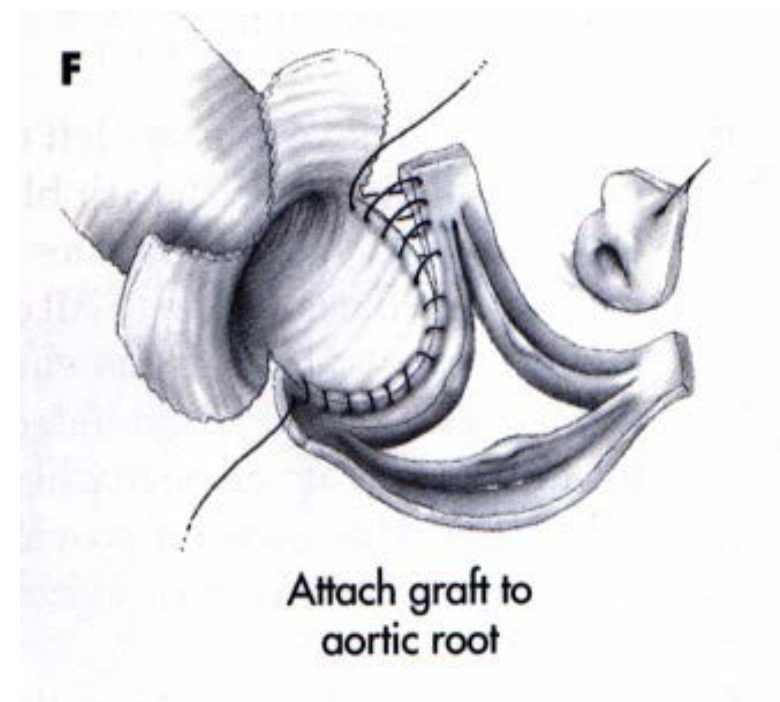
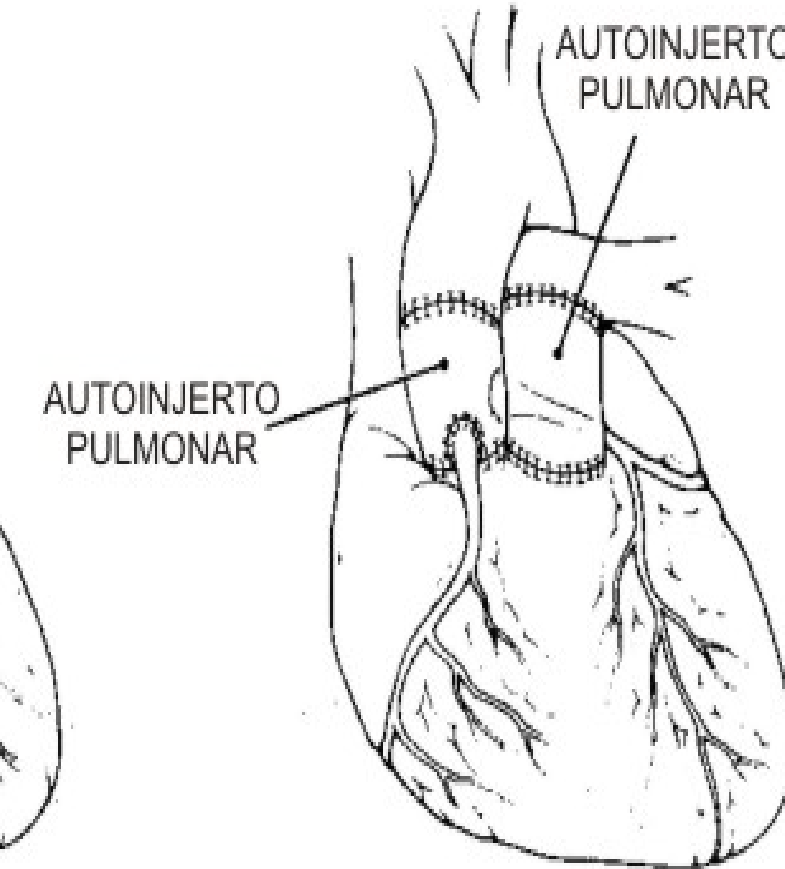
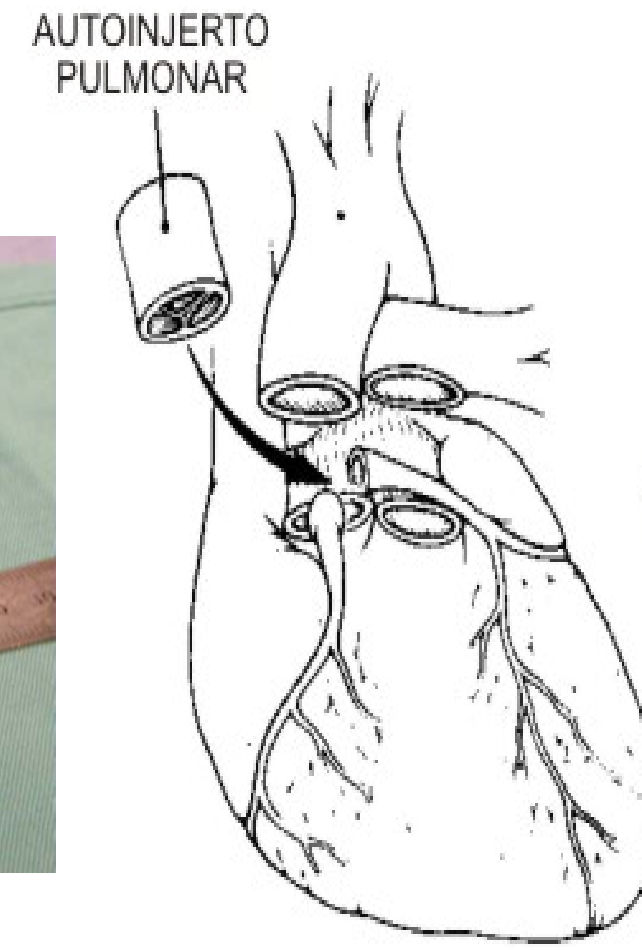
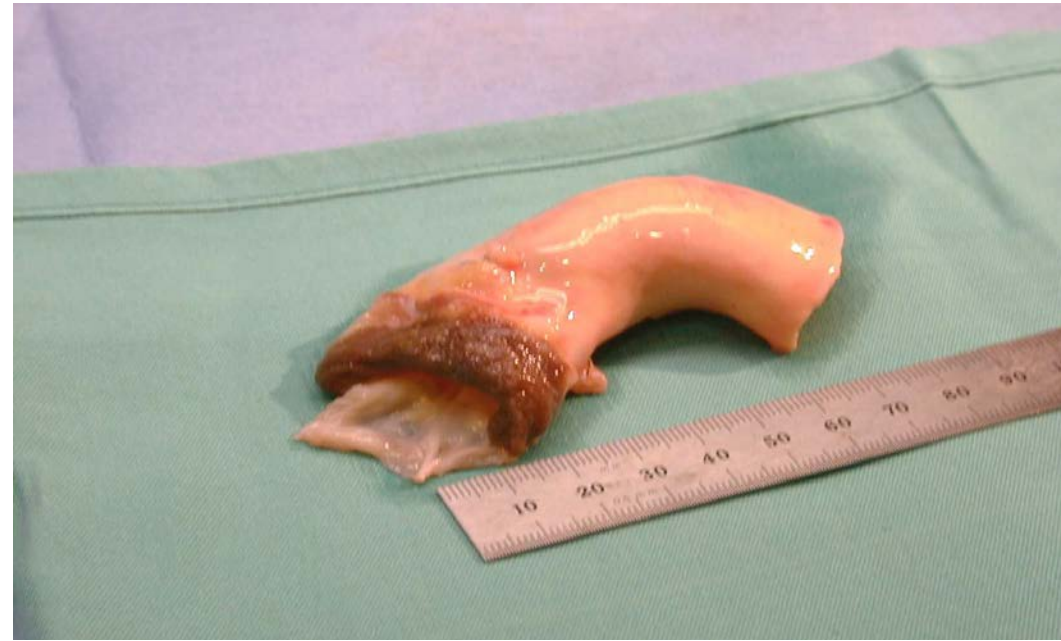
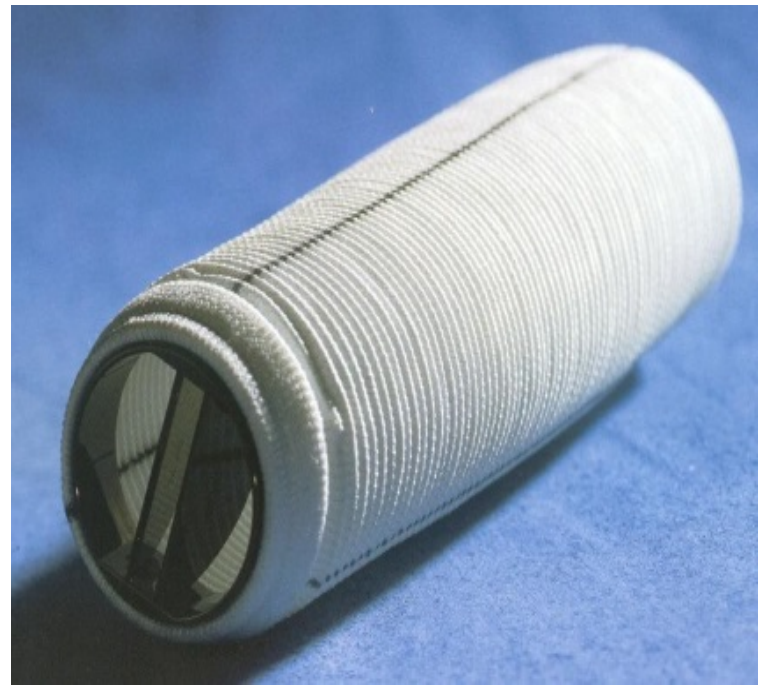
A technique for complete replacement of
the ascending aorta

HUGH BENTALL AND ANTONY DE BONO

From the Royal Postgraduate Medical School, London, and Hammersmith Hospital

Optimal Strategy for Aortic Root Replacement: Ross

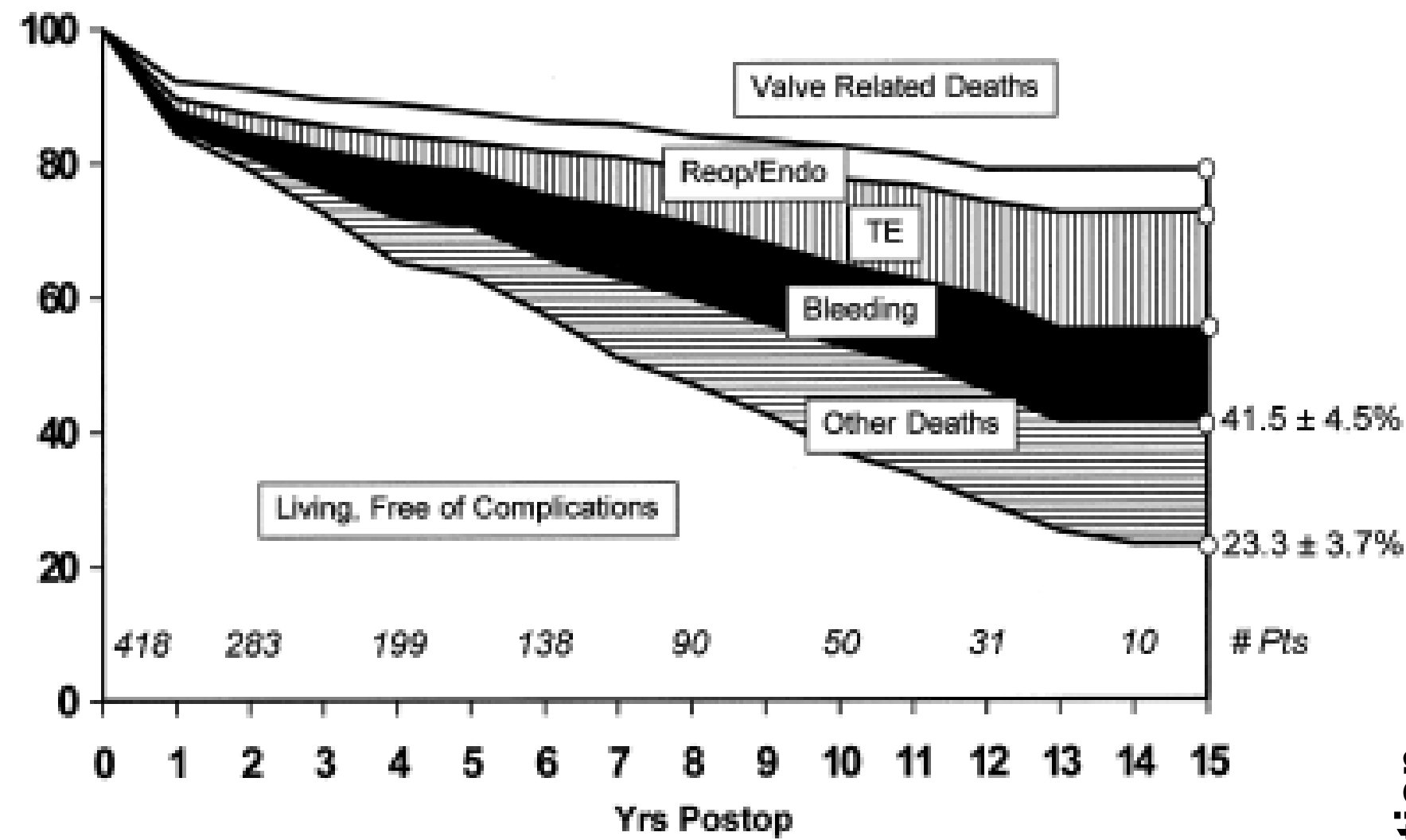
Surgical Options





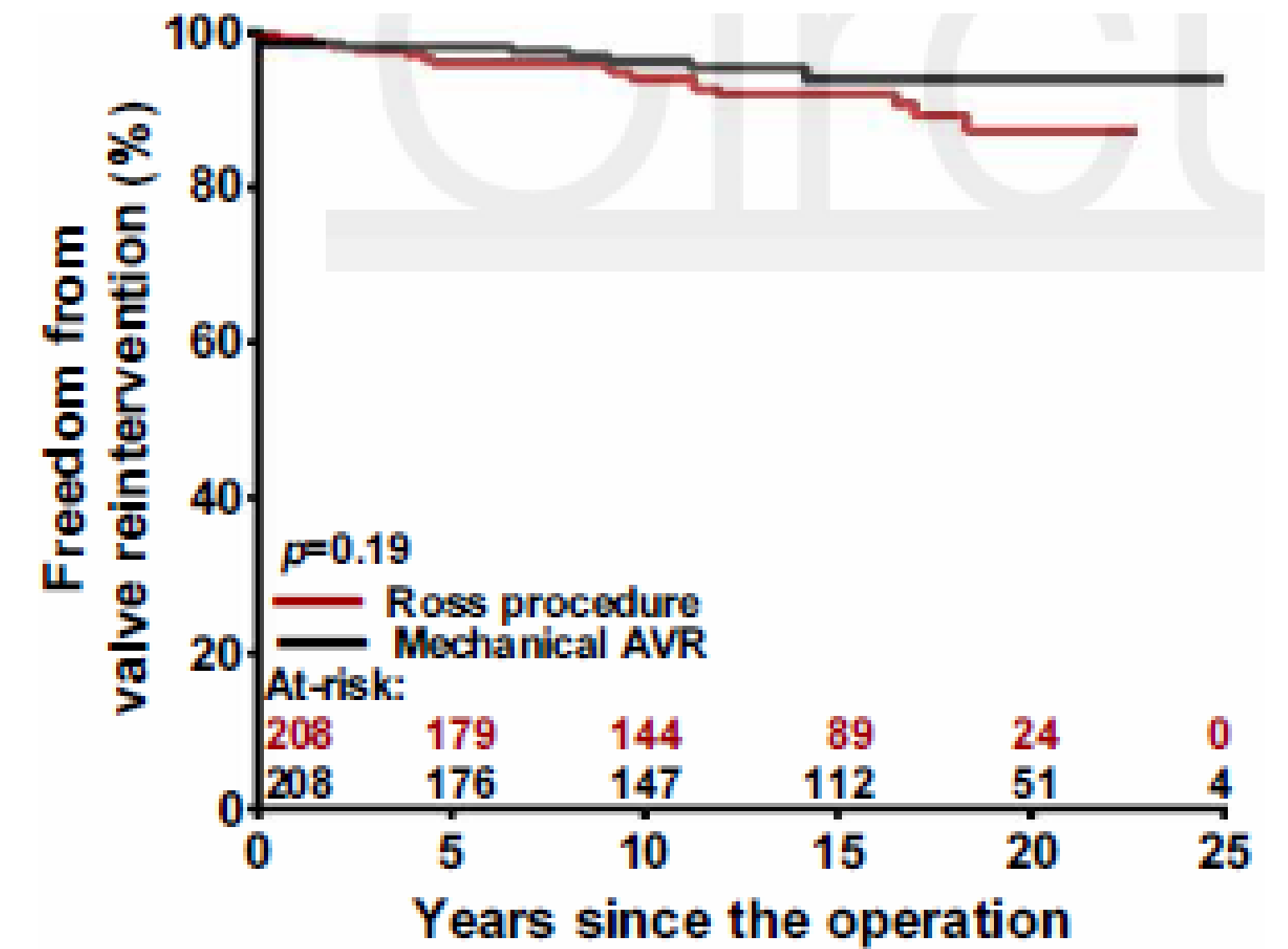
AORTIC VALVE REPLACEMENT

Mechanical Prosthesis



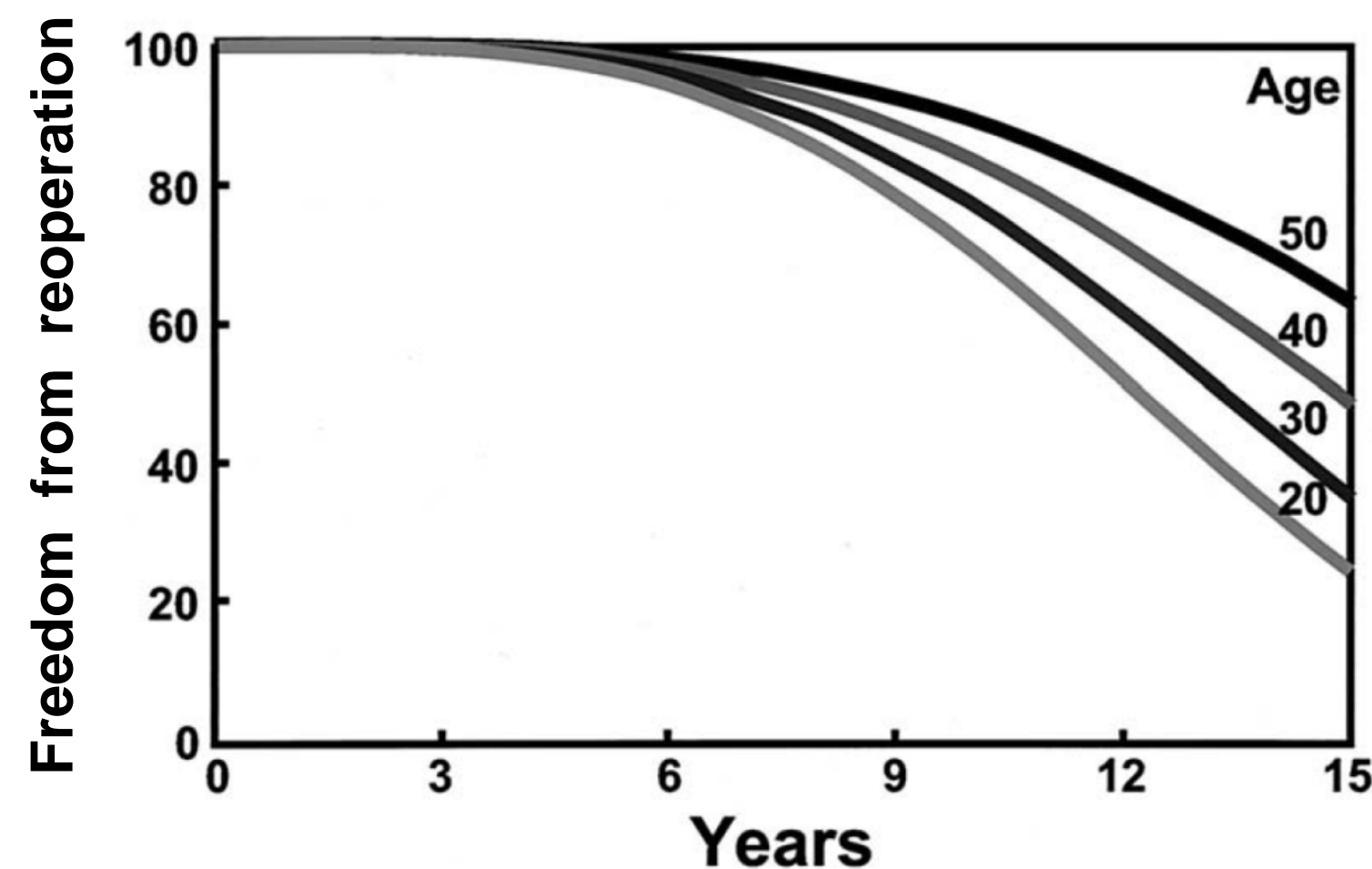
Zellner et al Ann Throac Surg 1999;68:1210-1218

Mechanical Prosthesis & Ross Procedure



Mazine A. et. al. Circulation 2016 Aug 23; 134(8):576-85

Biological Prosthesis



Svensson et al. Curr Probl Cardiol 2003;28:417-480

AORTIC VALVE REPLACEMENT

Mechanical Prosthesis

Mechanical AVR is not Risk Free

Linearized Rates

Thromboembolic 1-3%/year

Hemorrhage 1-3%/year

Total 2-6%/year

Grunkemeier, et al. Curr Prob Card 2000

Ross procedure

Aortic valve selection procedure is an unsolved issue because there is no ideal valve substitute developed up to now.

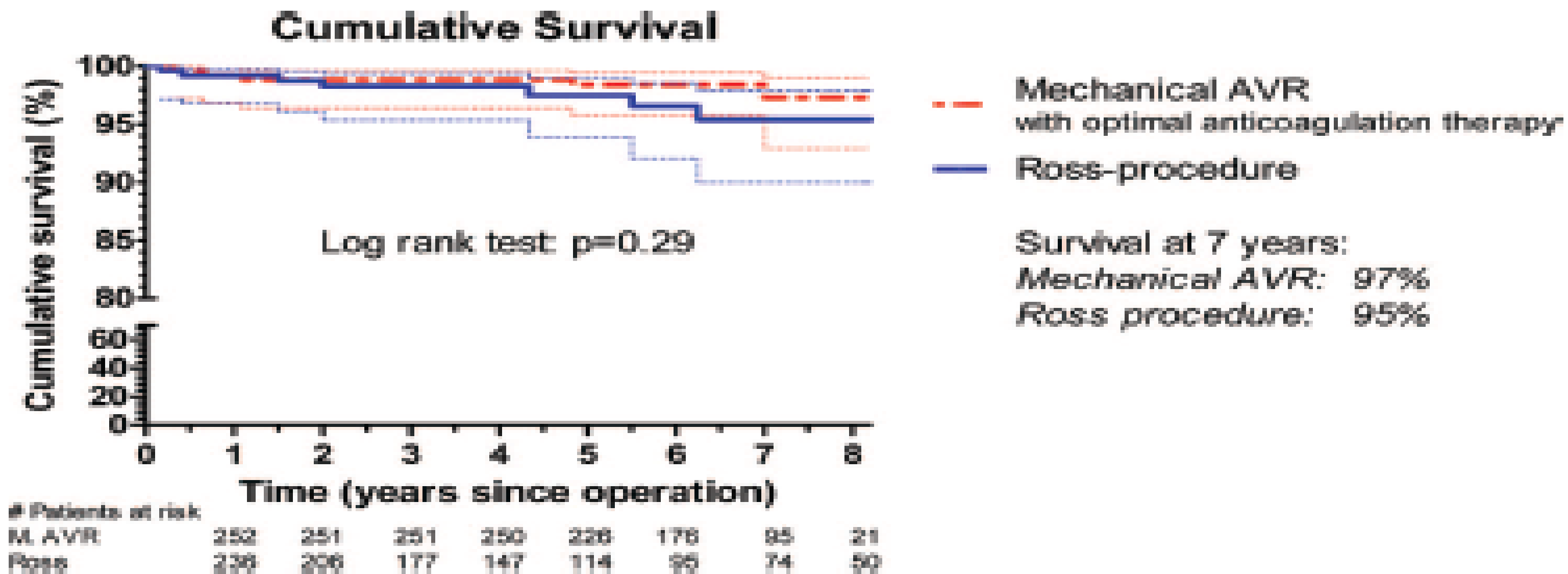
Main Concerns

Technically demanding

Autograft

Homograft

Ross procedure



Kaplan-Meier plot for all-cause mortality by procedure (Ross procedure vs mechanical valve replacement with optimal self-management anticoagulation therapy). AVR indicates aortic valve replacement.

Circulation 2011; 123:31-38

Ross procedure

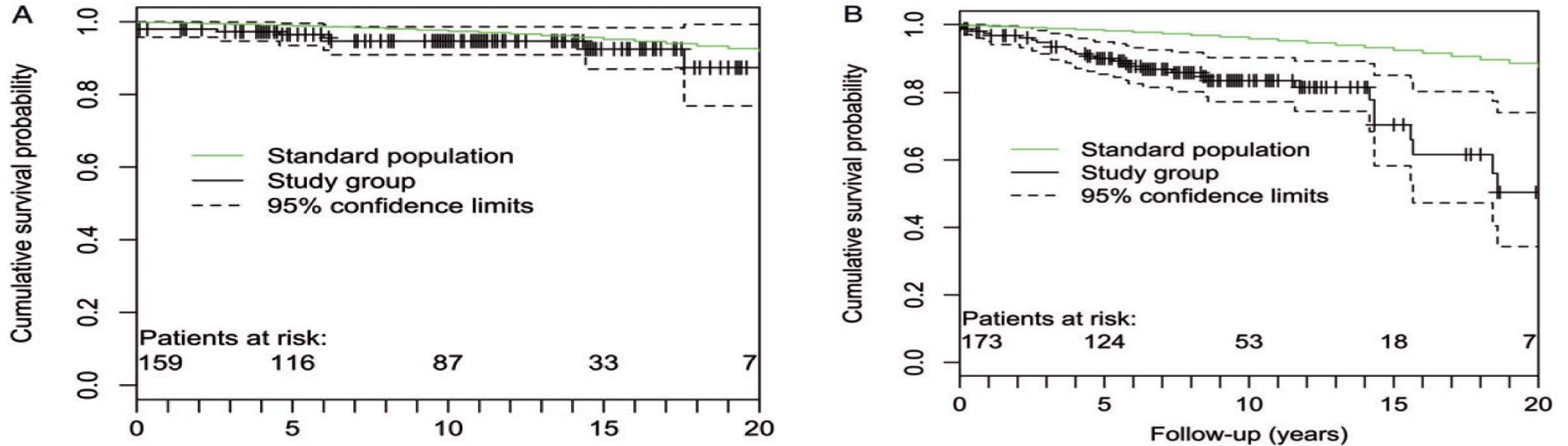
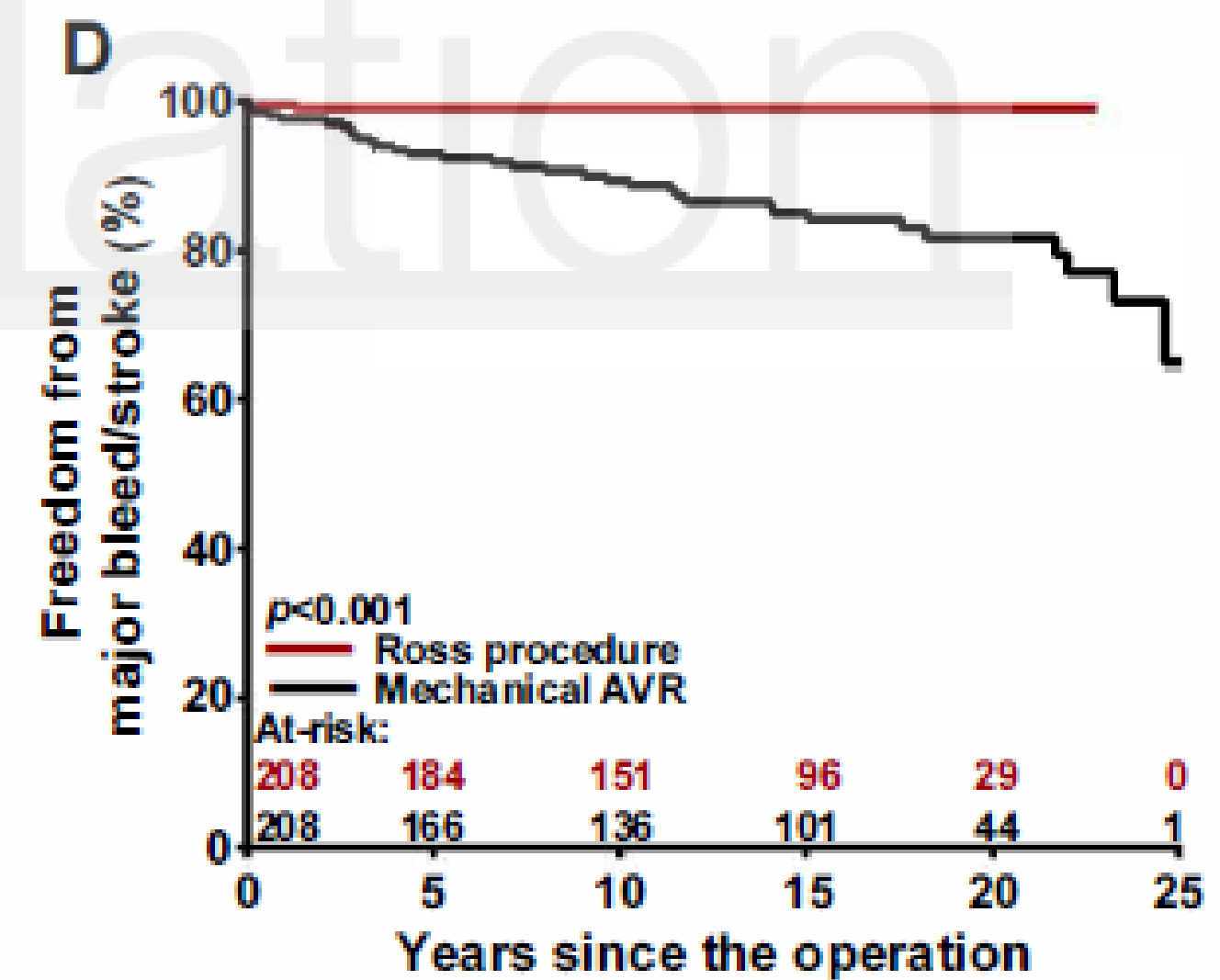
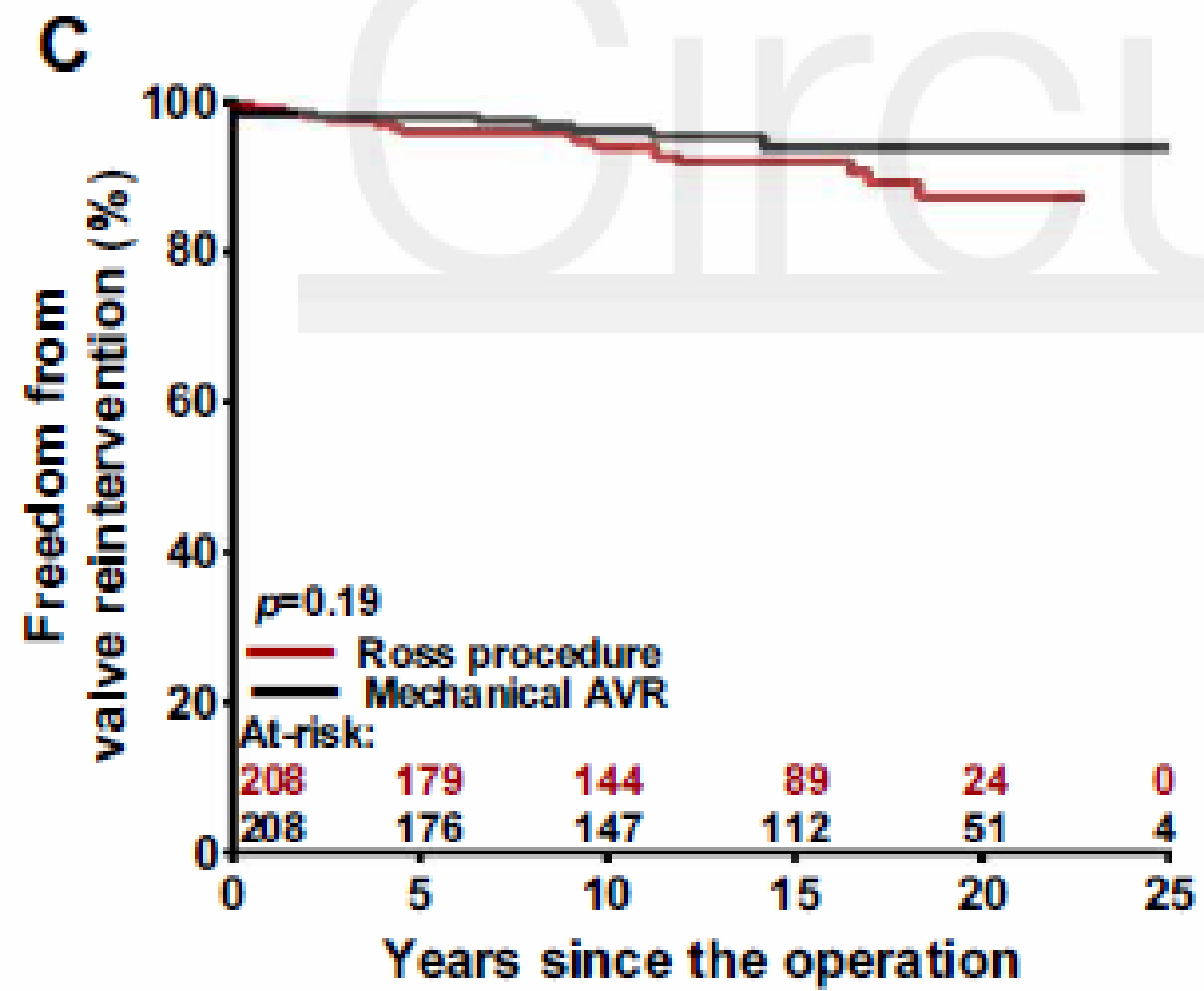
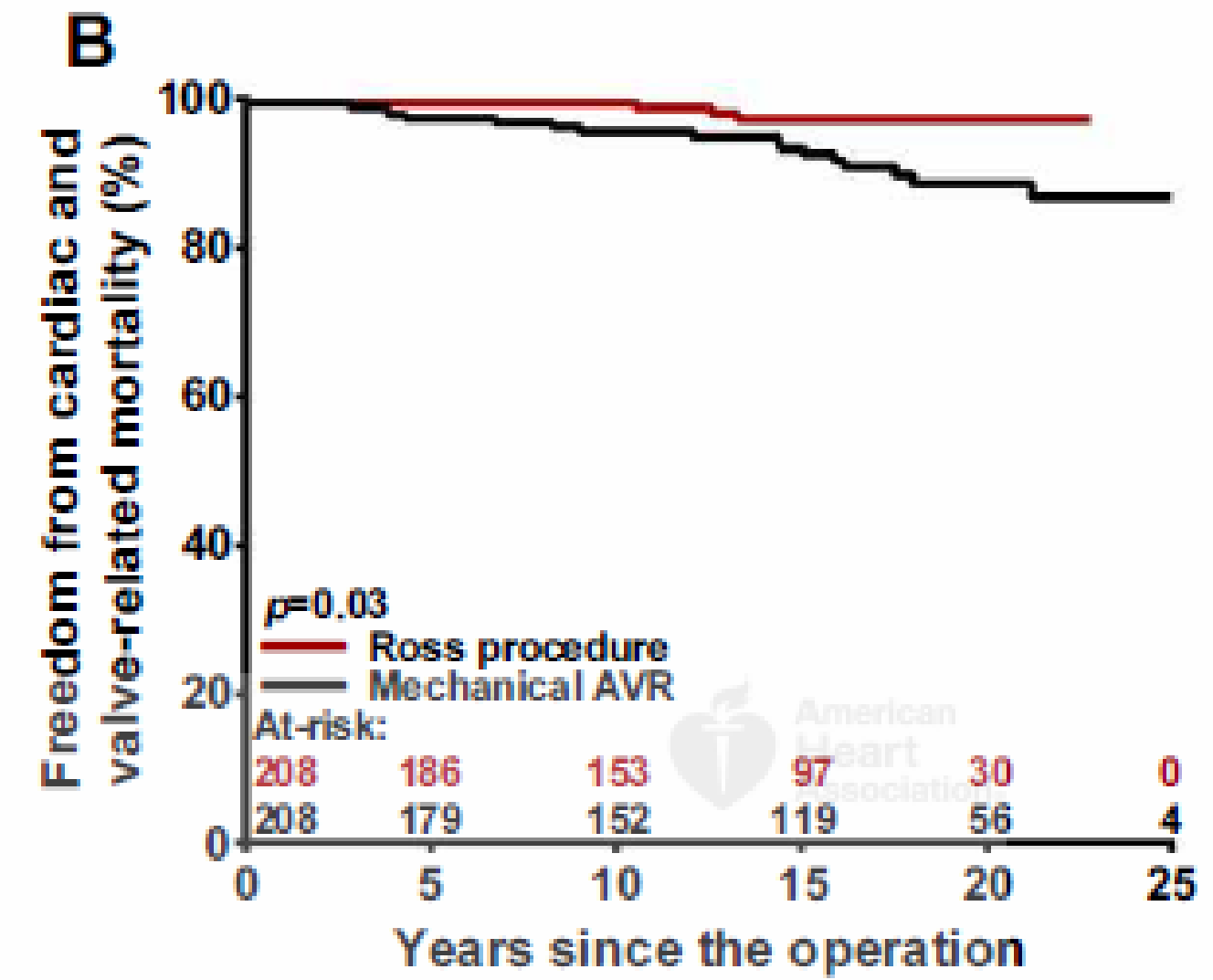
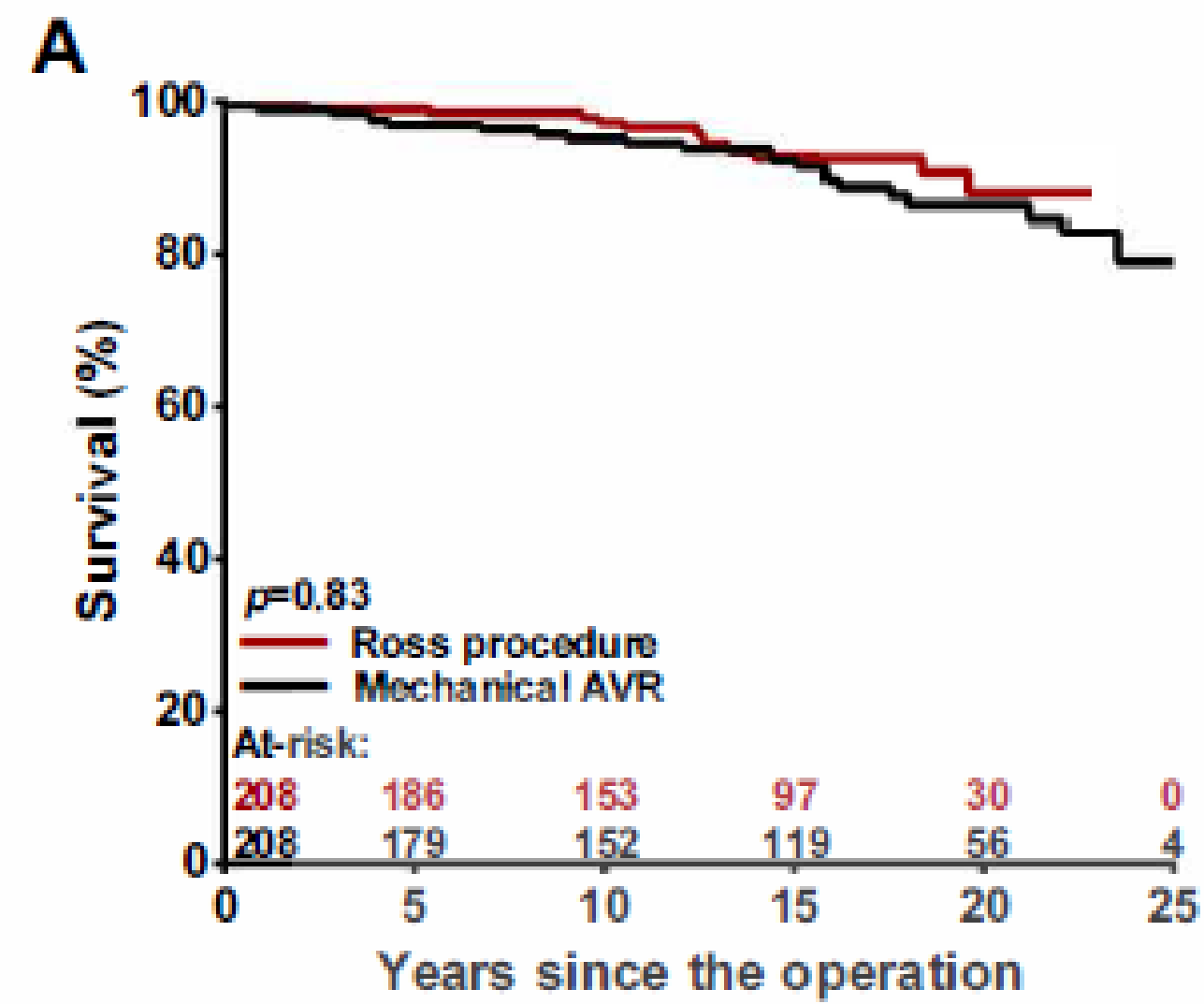


Figure 1: Survival in comparison to the age- and sex-matched Austrian population. (A) Ross population. (B) Patients with mechanical aortic heart valves.



Society of Thoracic Surgeons Clinical Practice of Aortic Valve and Ascending Aorta Guidelines

10. Pulmonary Autograft (Ross Procedure)— Recommendations

Class I

1. The Ross procedure is recommended **in infants** and **small children** for whom no satisfactory alternative valve substitute exists. (Level of evidence C)

Class IIb

1. The Ross procedure may be considered **in older children and young adults** because of **low operative risk**, but patients and their families must be informed of the possible need for **reoperation** which increases over time. (Level of evidence C)

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)

IIb

C

Replacement of the aortic valve by a pulmonary autograft (the Ross procedure), when performed by an experienced surgeon, may be considered for young patients when VKA anticoagulation is contraindicated or undesirable (167-169).

2014 recommendation remains current.

J Am Coll Cardiol 2017 Jul 11;70(2):252-289

Feasibility of the Ross Procedure: Its Relationship with the Bicuspid Aortic Valve

Roberto Favaloro, Pablo Stutzbach, Carmen Gomez, Alejandro Machain, Horacio Casabe

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Background and aim of the study: The feasibility of the Ross procedure, and which patients benefit most from its performance, have not yet been fully established. The study aim was to analyze the relationship between the etiology of aortic valve disease, the feasibility of performing the Ross procedure, and late pulmonary autograft performance.

Methods: Between June 1995 and June 2001, 117 patients (77 males, 40 females; mean age 37 ± 12 years) underwent the Ross procedure at the authors' institution. Of these patients, 53 (45.3%) had severe aortic stenosis, 53 (45.3%) had significant aortic insufficiency, four (3.4%) had active endocarditis, two (1.7%) had subaortic stenosis, and five (4.3%) had prosthesis dysfunction. Eighty-one patients (69%) had a bicuspid aortic valve. Pulmonary autograft dysfunction was defined as regurgitation grade ≥ 2 , as registered by Doppler echocardiography.

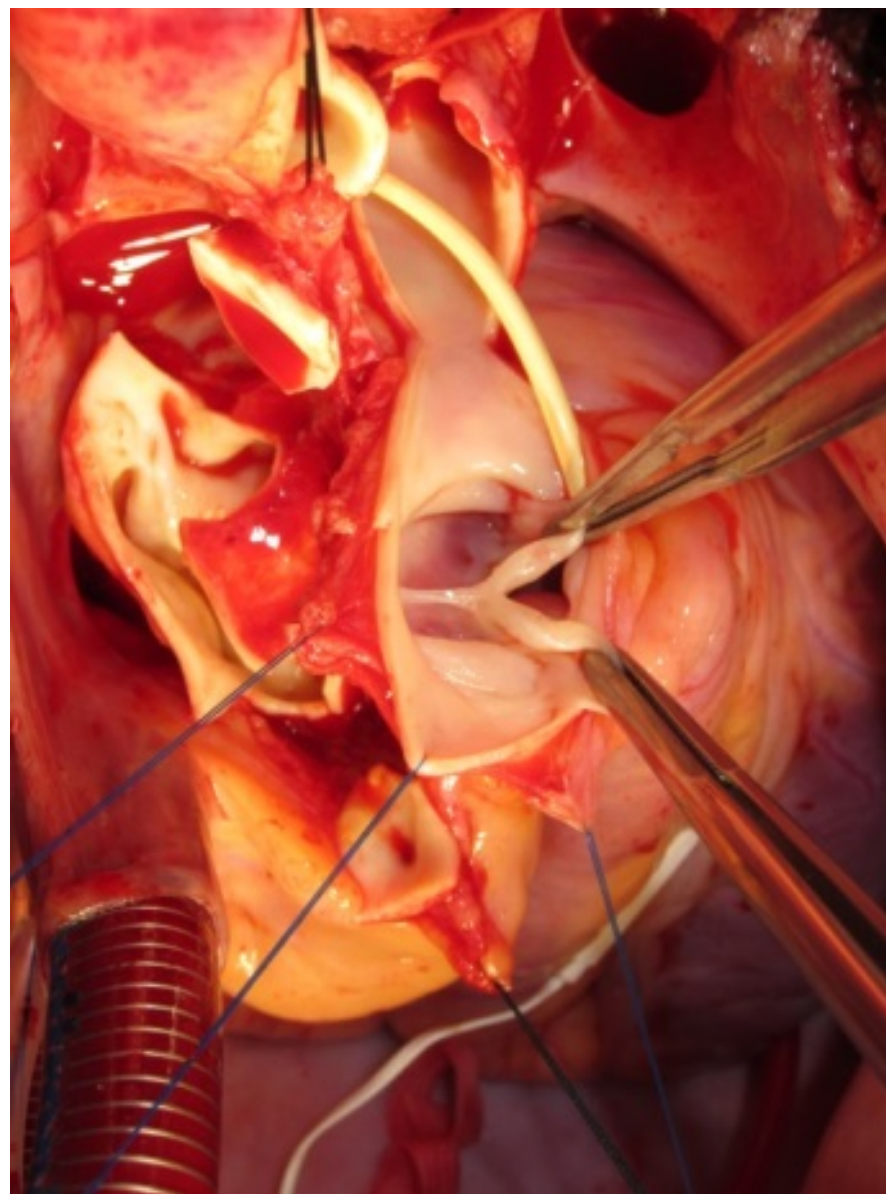
Results: The Ross procedure was successful in 100 patients (85.5%); hospital mortality was 2.6% ($n = 3$). The procedure was not feasible in 17 patients (14.5%); of these, seven had bicuspid pulmonary valve, six had >3 mm multiple pulmonary valve fenestrations, three had severe pulmonary insufficiency, and one patient had dissection-related pulmonary

valve injury. Twelve of 16 patients presenting with pulmonary valve defects had bicuspid aortic valve ($p = 0.04$). At six-year follow up, the probability of not requiring reoperation was 93% (confidence interval 86-100%). During follow up (30 ± 14 months; range: 2-72 months), six patients presented with grade 2 pulmonary autograft insufficiency, three with grade 3, and two with grade 4. Six of the latter 11 patients ($p = 0.03$) had a history of bicuspid aortic valve with aortic regurgitation. Freedom from autograft dysfunction was 87% (confidence interval 82-92%). Patients with bicuspid aortic valve and aortic valve regurgitation had a higher tendency towards autograft dysfunction than those with bicuspid aortic valve and aortic stenosis (65% versus 100%, $p = 0.004$).

Conclusion: The feasibility of performing the Ross procedure is high, unless there is presence of bicuspid aortic valve. Patients with bicuspid aortic valve and a history of aortic insufficiency tend to develop moderate autograft dysfunction during long-term follow up.

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The Journal of Heart Valve Disease 2002;11:375-382



Ross Procedure in Adults: Is Reoperation a Real Concern?

Maria C. Escarain, Gustavo Giunta, Roberto R. Favalloro

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Background and aim of the study: Reintervention after the Ross procedure (RP) remains a concern. Hence, the study aim was to assess the long-term results of the RP in adults and to identify predictors of reoperation.

Methods: Between 1995 and 2012, a total of 263 consecutive patients (189 males, 74 females; mean age 42 ± 14 years) underwent the RP, using the free-standing root technique. The mean follow up was 7.5 ± 5.0 years and was 94% complete. Survival, and freedom from autograft, homograft and Ross-related reoperation were analyzed using Kaplan-Meier analysis, while Cox proportional hazard regression was used to identify predictors of reoperation.

Results: Early mortality was 2.6% (n = 7) and late mortality 4.9% (n = 14). Survival at 13 years was 90% (95% CI 80-95%). Freedom from homograft, autograft and Ross-related reoperation at 13 years were 97%

(95% CI 90-99%), 92% (95% CI 82-96%) and 90% (95% CI 81-95%), respectively. No predictors of homograft reoperation were identified. Freedom from autograft reoperation was not significantly different for patients with preoperative aortic insufficiency (AI) (88%; 95% CI 74-95% at 13 years) compared to those with aortic stenosis (96%; 95% CI 84-99% at 13 years), or both (86%; 95% CI 51-97% at 13 years) (p = 0.62). Other variables (gender, aortic/pulmonary mismatch and aortic annulus diameter) were not significantly associated with the need for autograft reoperation.

Conclusion: Despite its complexity and reoperation rate, RP should be considered as a valid surgical option for aortic valve disease treatment in selected patients. Among the present series, no predictors for homograft or autograft reoperation were identified.

The Journal of Heart Valve Disease 2015;24:247-252

Ross Procedure: 20-years Experience

Favaloro Foundation University Hospital | Favaloro University
Ciudad Autónoma de Buenos Aires, Argentina



- **May 1995 - December 2015**
- **283 consecutive patients**
- **Surgical technique: free-standing root and aortic annular reinforcement with pericardium**
- **The same surgeon performed 94% of the procedures.**
- **Clinical follow-up was 90% complete**
- **Mean follow-up was 9.3 ± 5.5 years**

Demographic and clinical characteristics of the patients

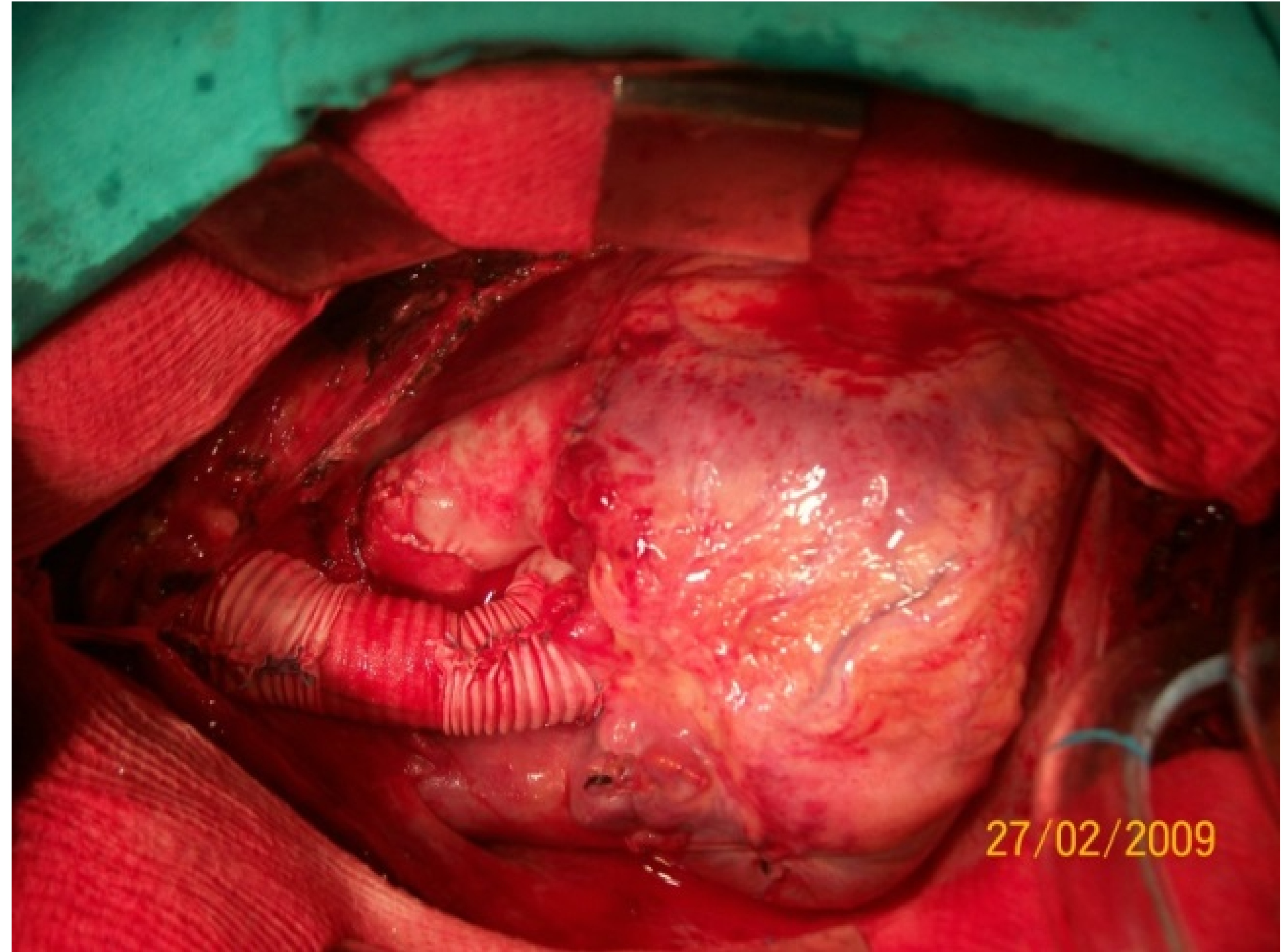
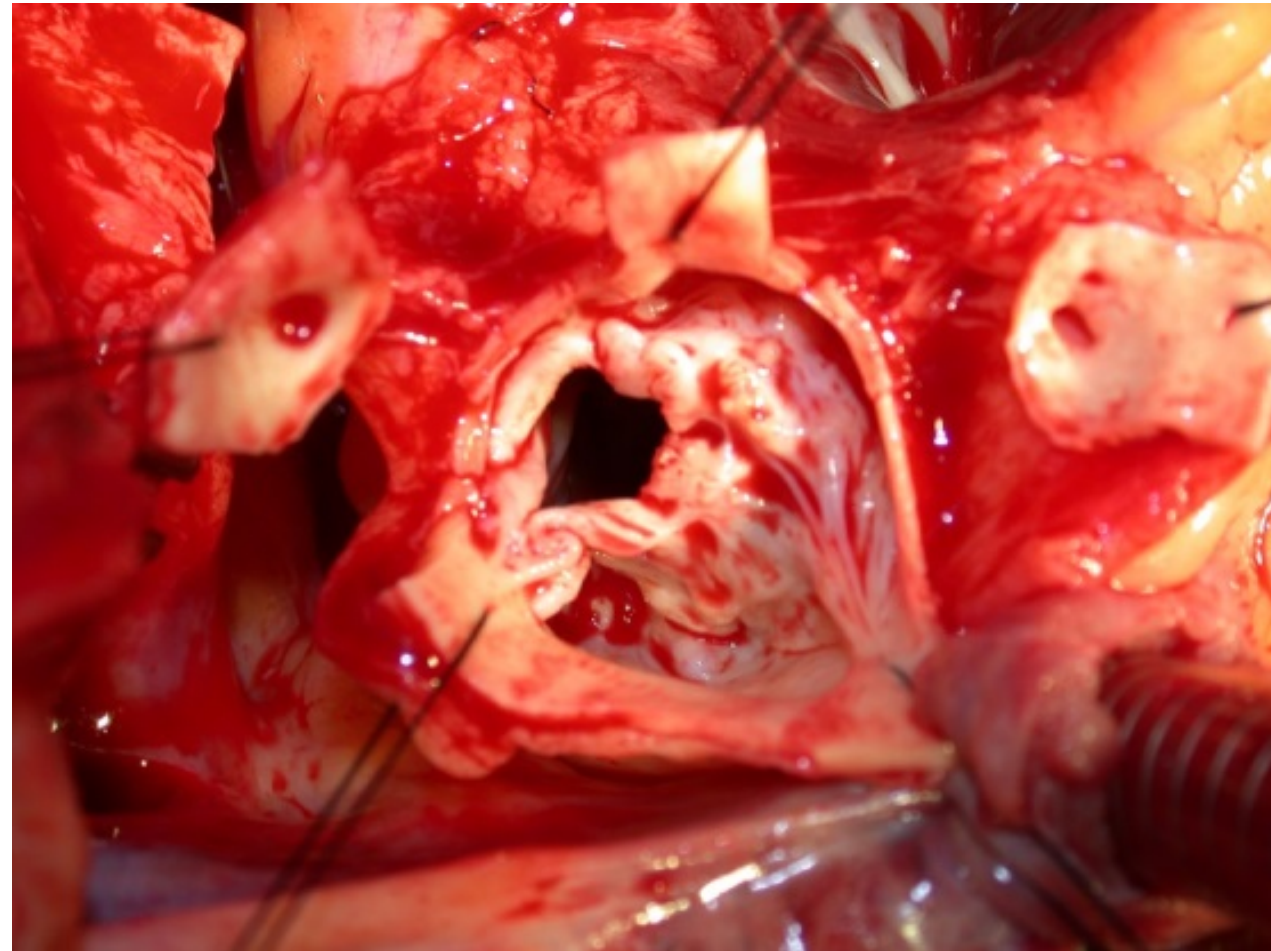
	n (%)
Age (years) ^a	42 (29-54)
Sex	
Male	205 (72.4)
Female	78 (27.6)
Diabetes mellitus	7 (2.5)
Social status	
Indigent	92 (32.5)
Non-indigent	191 (67.5)
NYHA functional class	
I-II	227 (80.2)
III-IV	56 (19.8)
LVEF (%)	57.8 (54-65)
>50%	231 (81.6)
30-50%	52 (18.4)
<30%	-
Previous cardiac surgery	21 (7.4)
^a Values are expressed as median (interquartile range). NYHA: New York Heart Association, LVEF: left ventricular ejection fraction	

Demographic and clinical characteristics of the patients

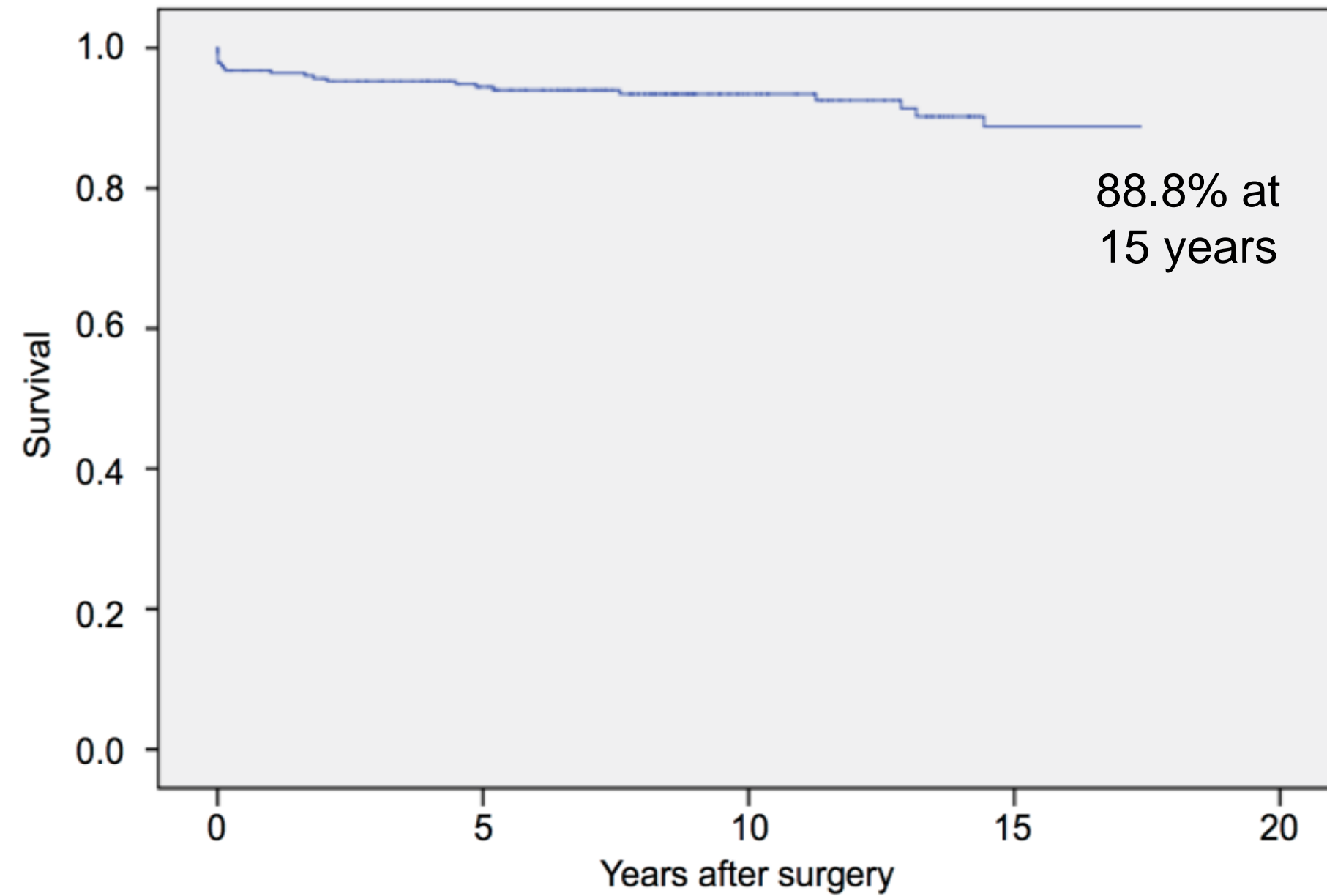
	n (%)
Cardiac rhythm	
Sinus rhythm	279 (98.6)
Atrial fibrillation	4 (1.4)
Preoperative aortic valve disease	
Aortic stenosis	143 (50.5)
Aortic insufficiency	99 (35)
Aortic stenosis / insufficiency	41 (14.5)
Etiology	
Bicuspid aortic valve	218 (77.0)
Infective endocarditis	25 (8.8)
Active infective endocarditis	8 (2.8)
Aortic root dilation	23 (8.1)
Rheumatic	17 (6.0)
Prosthetic dysfunction	11 (3.9)
Congenital aortic stenosis	9 (3.2)
Unicuspid aortic valve	5 (1.8)
Additive EuroSCORE ^a	5.4 (5-6)
Parsonnet score ^a	8.1 (6-9)
STS risk score ^a	0.58% (0.46-0.91)
Emergency/Urgencies	1(0.4) / 16(5.7)
^a Values are expressed as median (interquartile range).	

Surgical procedures

	n (%)
Isolated Ross procedure	145 (51.2)
Combined surgery	138 (48.8)
Ross + aortoplasty	75 (26.5)
Ross + CABG	14 (4.9)
Ross + ascending aorta replacement	13 (4.6)
Ross + myomectomy	10 (3.5)
Ross + mitral valve repair	7 (2.5)
Ross-Konno procedure	5 (1.8)
Ross + interventricular septal defect closure	4 (1.4)
Ross + CABG + aortoplasty	2 (0.7)
Ross + mitral valve replacement	2 (0.7)
Ross + subaortic membrane resection	2 (0.7)
Ross + mitral and tricuspid valve repair + aortoplasty	1 (0.4)
Ross + mitral valve commissurotomy	1 (0.4)
Ross + ascending aorta replacement + subaortic membrane resection	1 (0.4)
Ross + myomectomy + aortoplasty	1 (0.4)
CABG: coronary artery bypass surgery.	

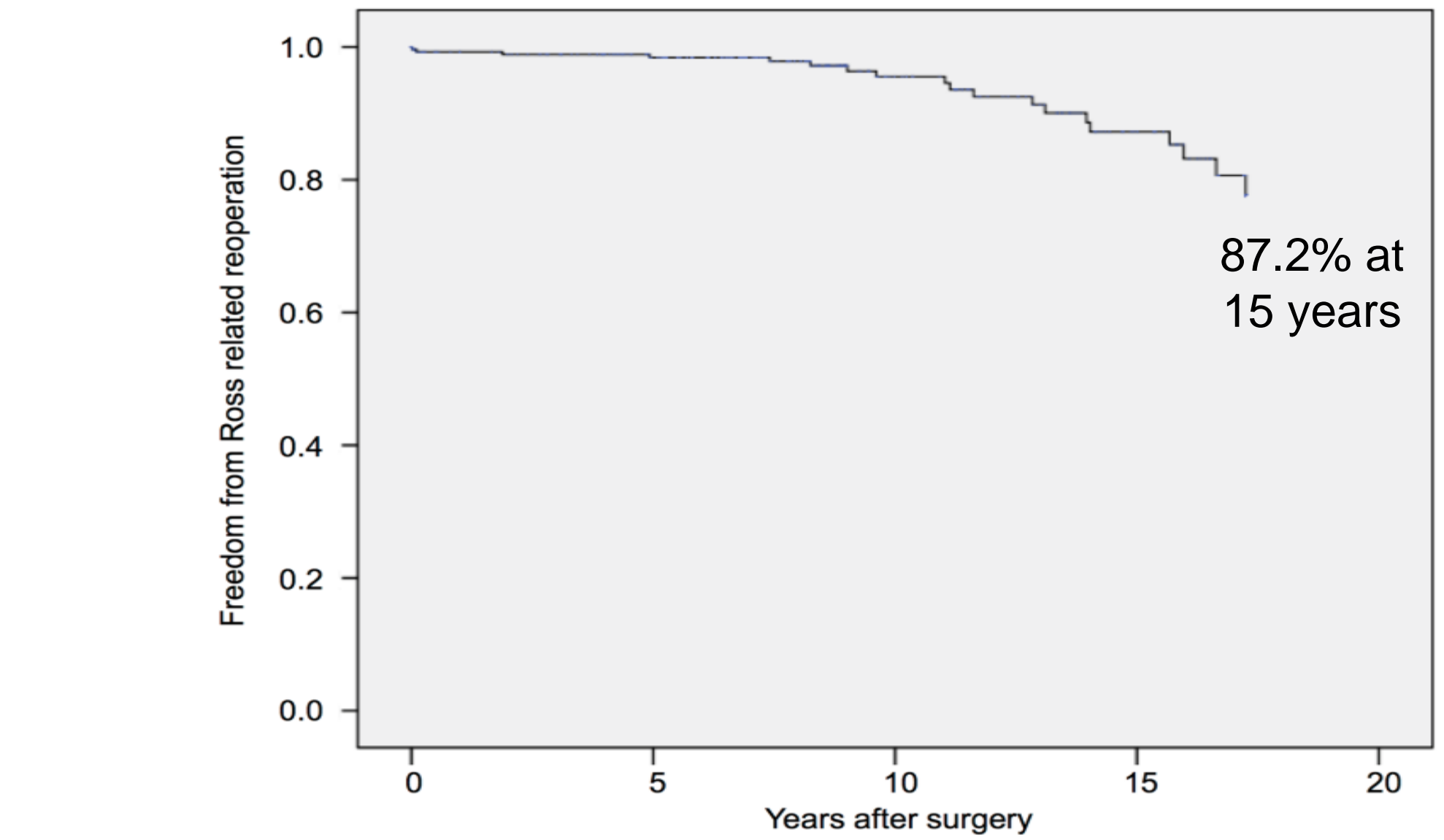


Survival after the Ross Procedure



Patients at risk / events 283 / 0 218 / 15 111 / 17 57 / 21

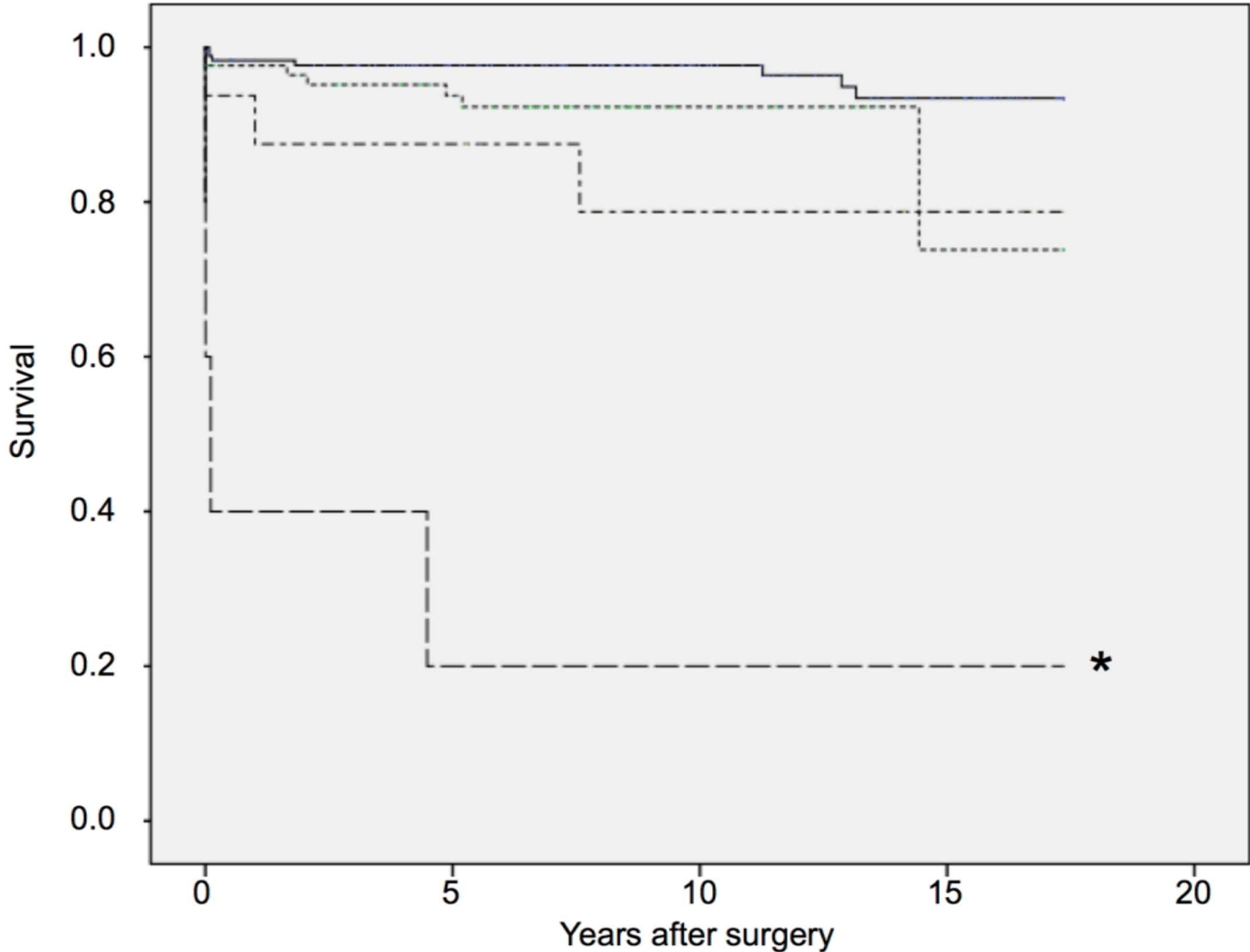
Freedom from Ross-related reoperation



Patients at risk / cumulative events

283 / 0 216 / 4 106 / 8 51 / 15

Survival according to age group and previous cardiac surgery

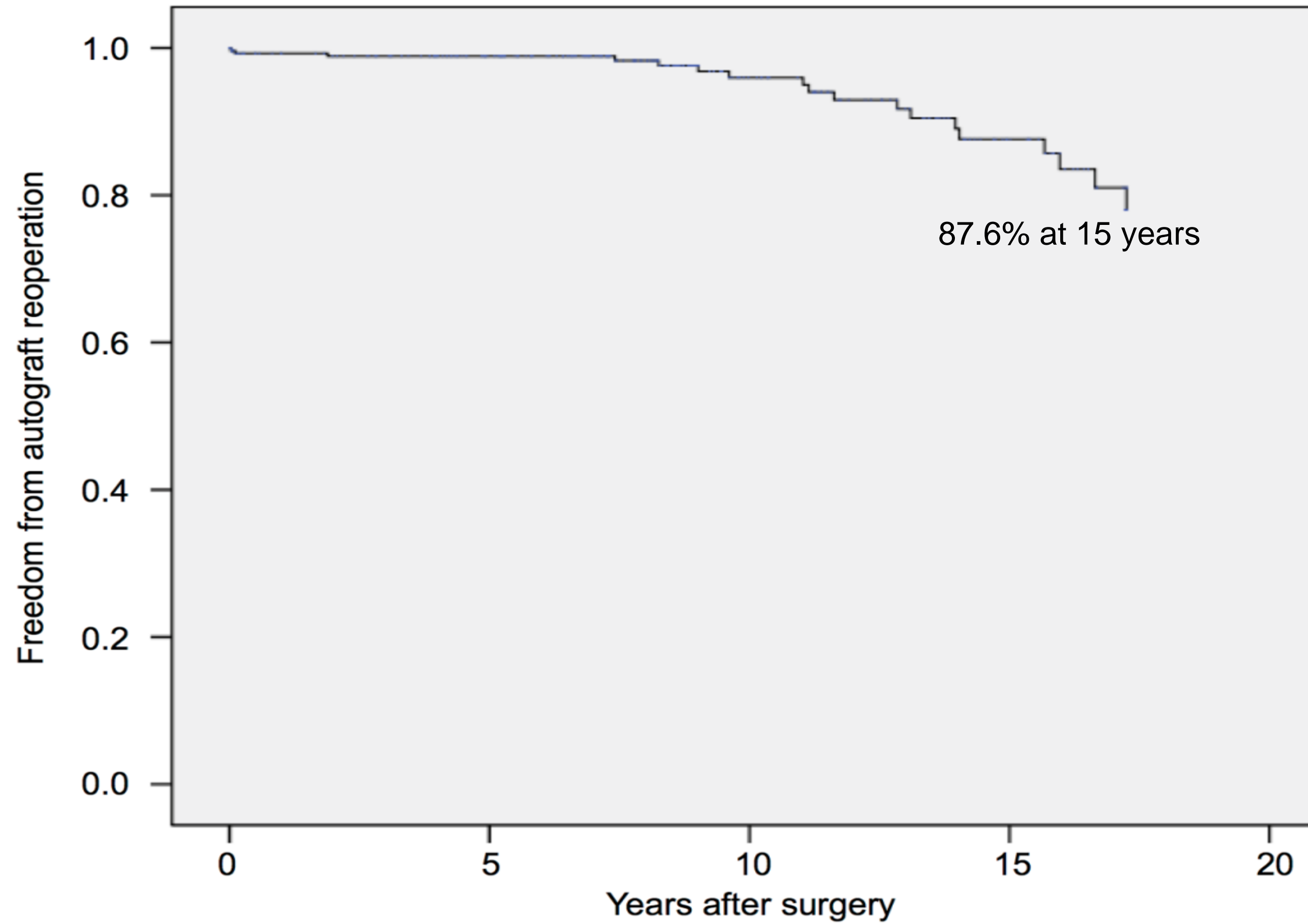


Patients at risk / cumulative events

≤ 50y + first-time surgery	177 / 0	137 / 4	84 / 4	50 / 7
> 50y + first-time surgery	85 / 0	66 / 5	19 / 6	3 / 7
≤ 50y + redo surgery	16 / 0	14 / 2	7 / 3	3 / 3
> 50y + redo surgery	5 / 0	1 / 4	1 / 4	1 / 4

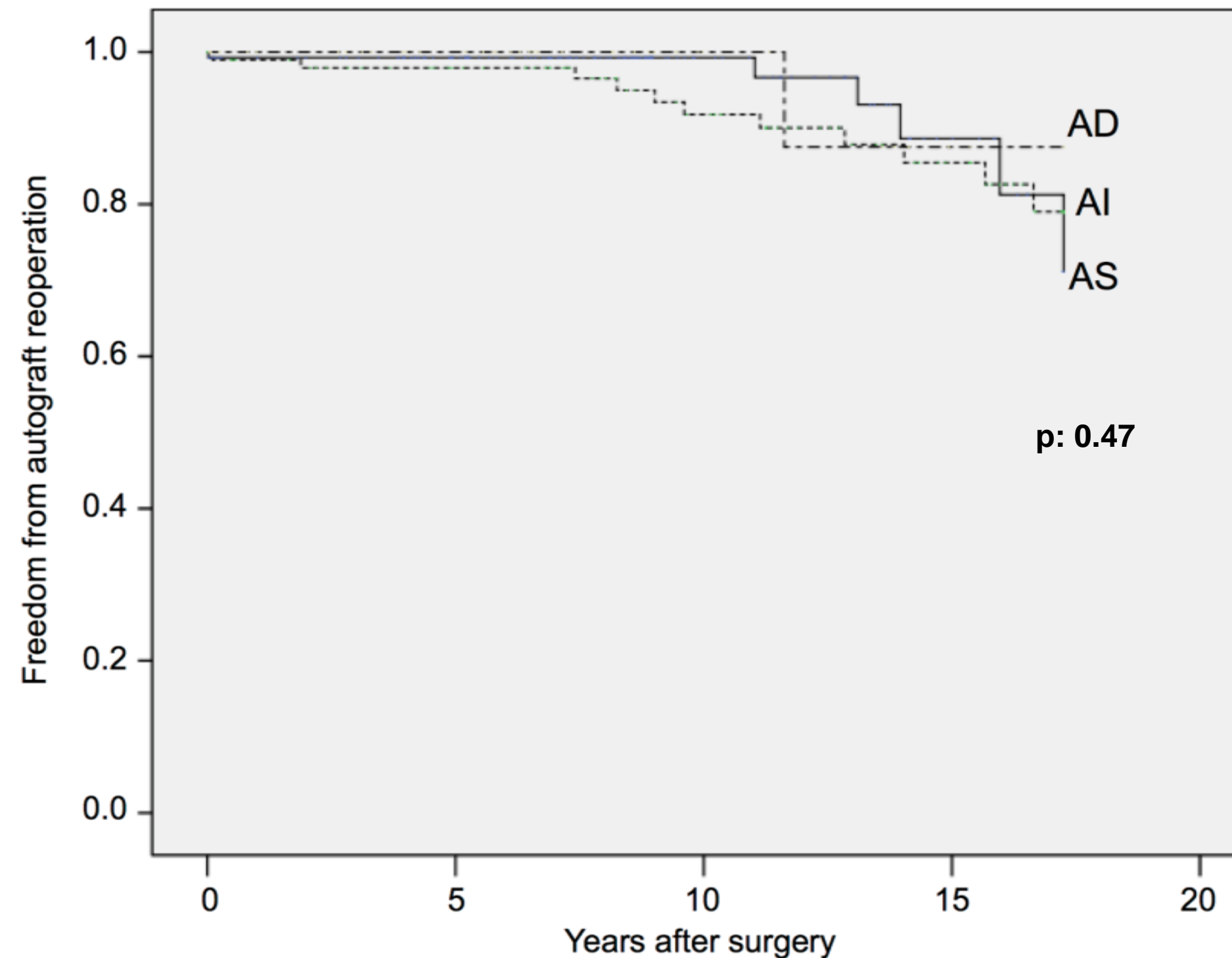
* p < 0.001 vs. reference group ≤ 50y + first-time surgery

Freedom from autograft reoperation



Patients at risk / events 283 / 0 216 / 3 106 / 7 51 / 14

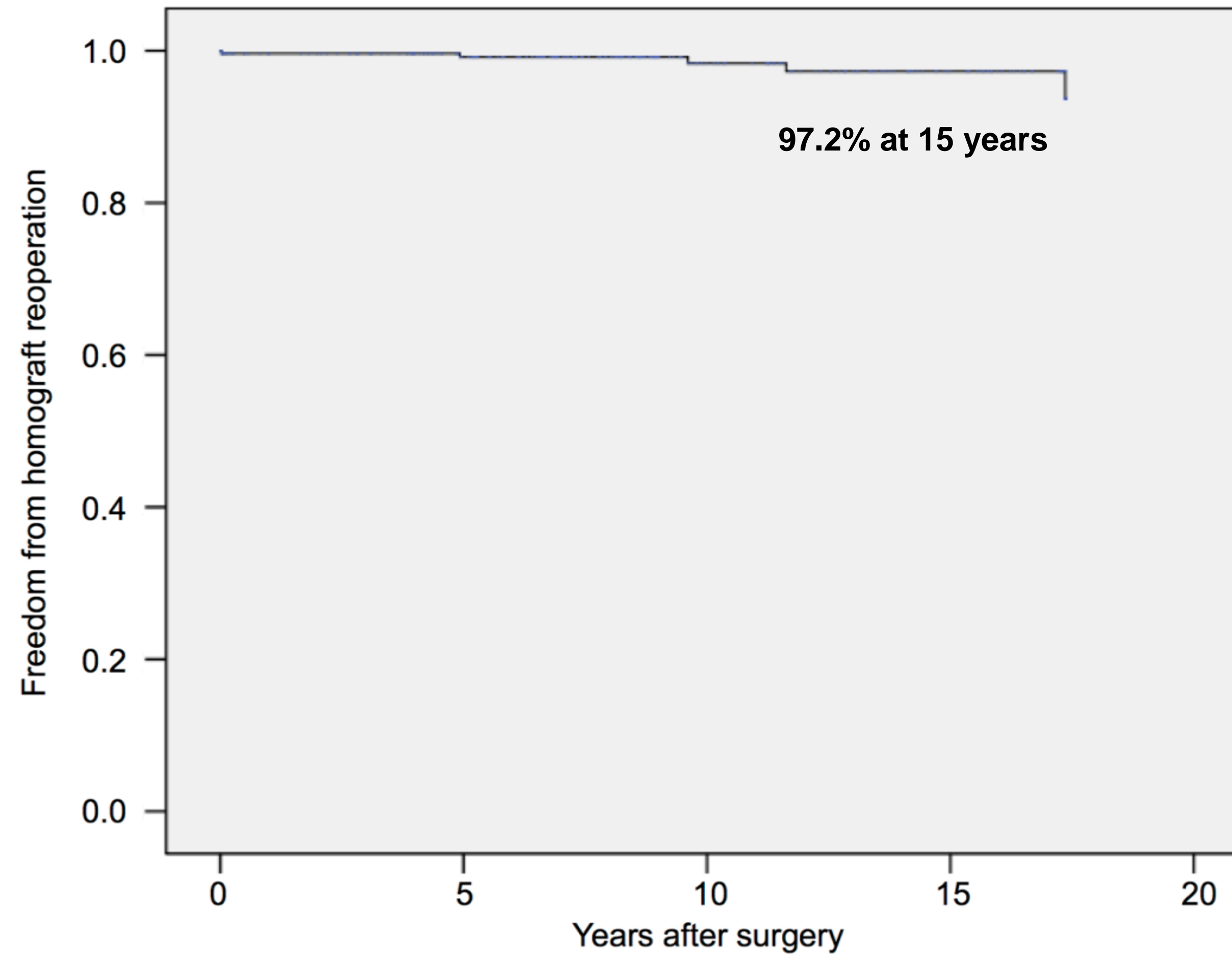
Freedom from autograft reoperation in patients with preoperative aortic stenosis, aortic insufficiency or aortic disease



Patients at risk / cumulative events

Aortic stenosis (AS)	143 / 0	105 / 1	41 / 1	16 / 4
Aortic insufficiency (AI)	99 / 0	82 / 2	56 / 6	32 / 9
Aortic disease (AD)	41 / 0	29 / 0	9 / 0	3 / 1

Freedom from homograft reoperation



Patients at risk / cumulative events

283 / 0

217 / 2

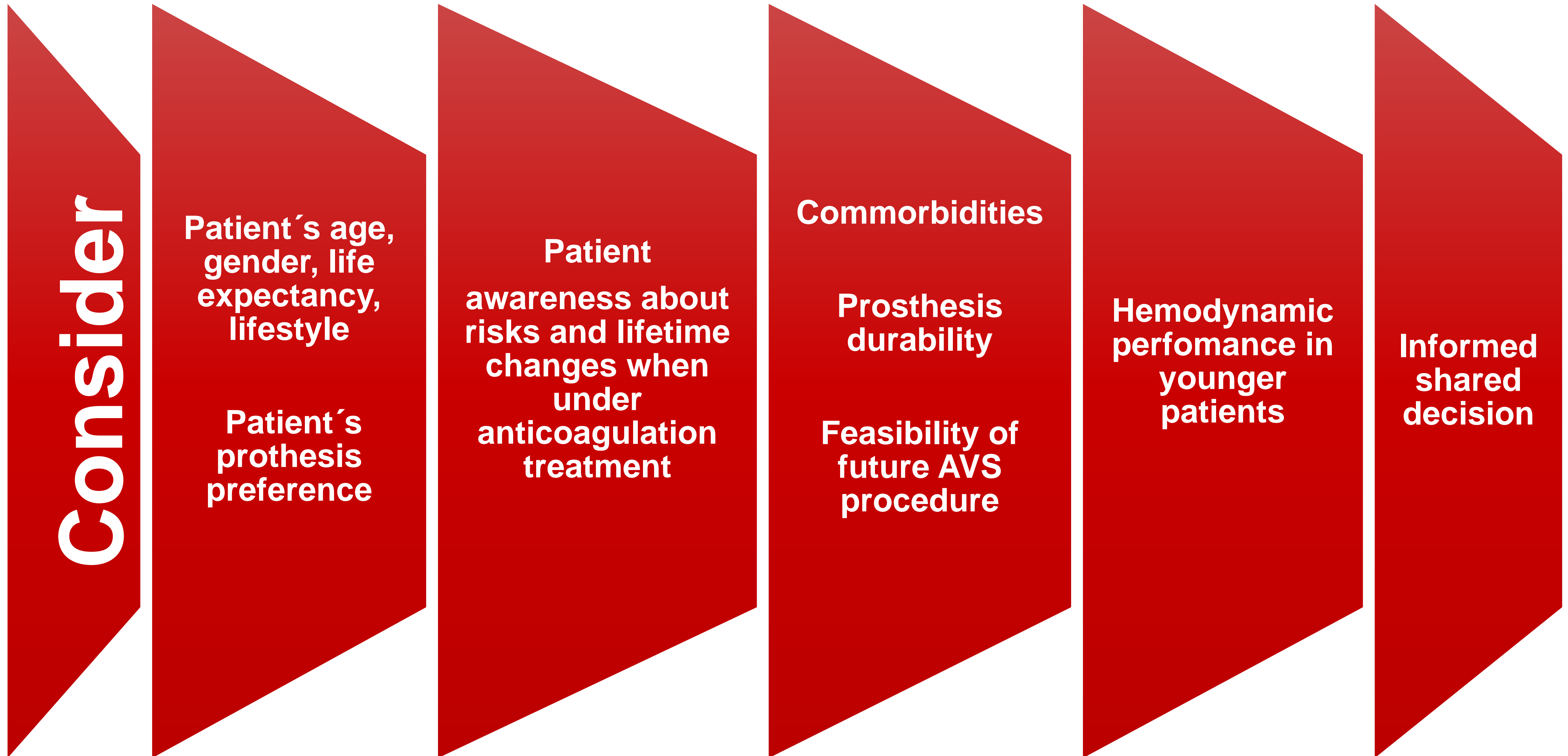
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Conclusions

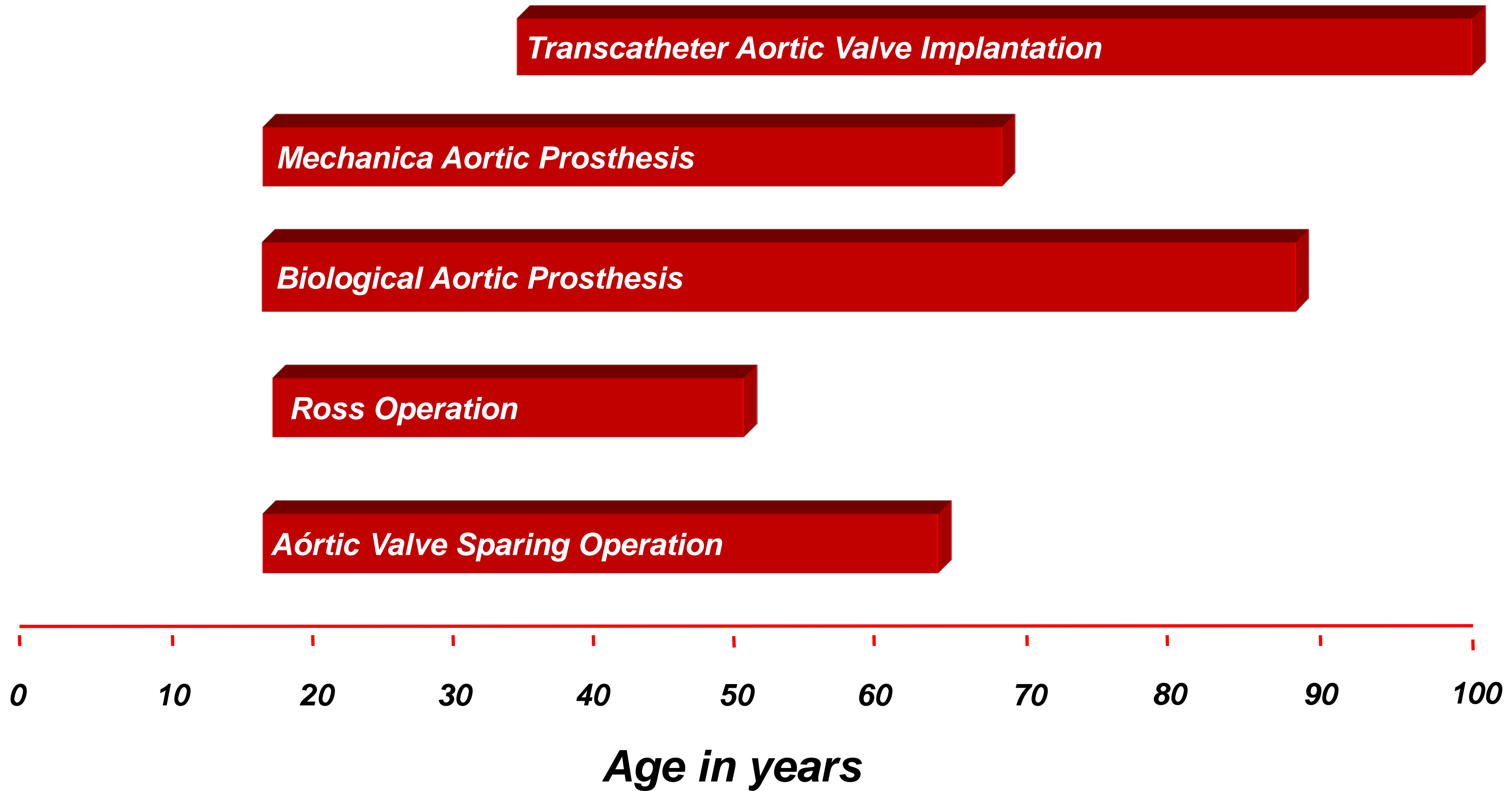
The Ross procedure shows encouraging results in selected patients younger than 50 years. At follow-up, no relationship was found between freedom of reoperation and survival regarding preop aortic annulus diameter, and BAV and AI or aortic dilation.

Optimal Strategy for Aortic Root Replacement: Ross



Optimal Strategy for Aortic Root Replacement: Ross





Postoperative complications

Complication	n (%)
Reoperation for bleeding/tamponade	18 (6.4)
IABP	14 (4.9)
ECMO + IABP	1 (0.4)
Centrifugal pump + IABP	3 (1.1)
Dialysis	2 (0.7)
Stroke	2 (0.7)
Permanent pacemaker	10 (3.5)
Deep sternal wound infection	4 (1.4)
ECMO: extracorporeal membrane oxygenation, IABP: intra-aortic balloon pump.	