Aortic Valve Replacement in the Young Adult

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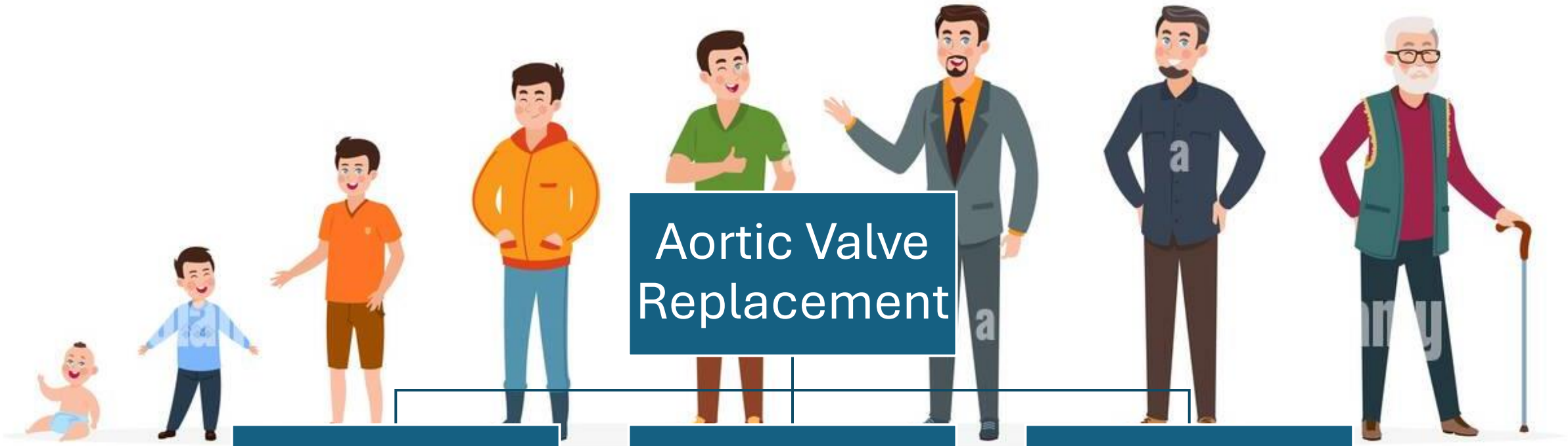


Aortic Valve Replacement

<55 years

55-75 years

>75 years

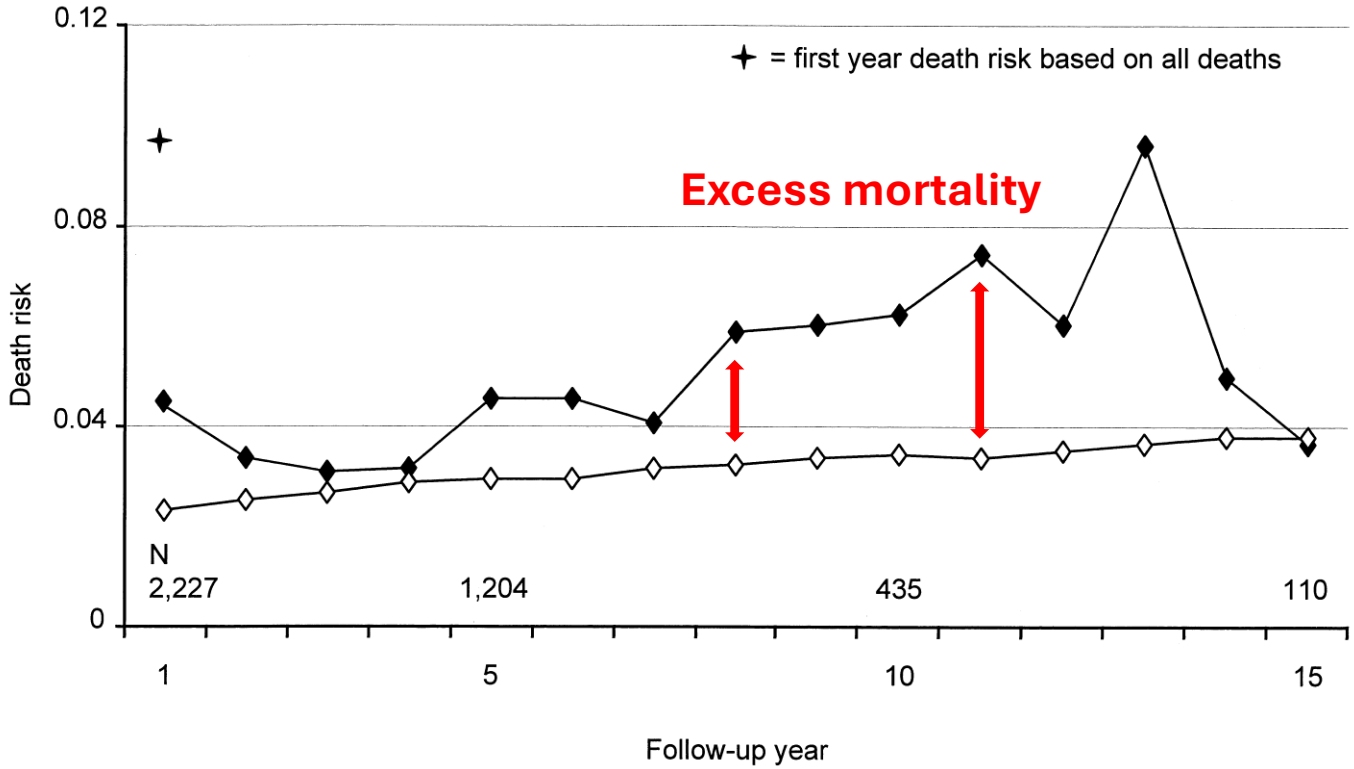
Conventional AVR in the young → excess long-term mortality

Sweden National Registry

2,359 patients underwent primary AVR

2,227 were alive at 30-day → long-term follow up

Mean age was 63 years for men (64%) and 67 years for women (46%)



Kvidal P, et al. J Am Coll Cardiol (2000)

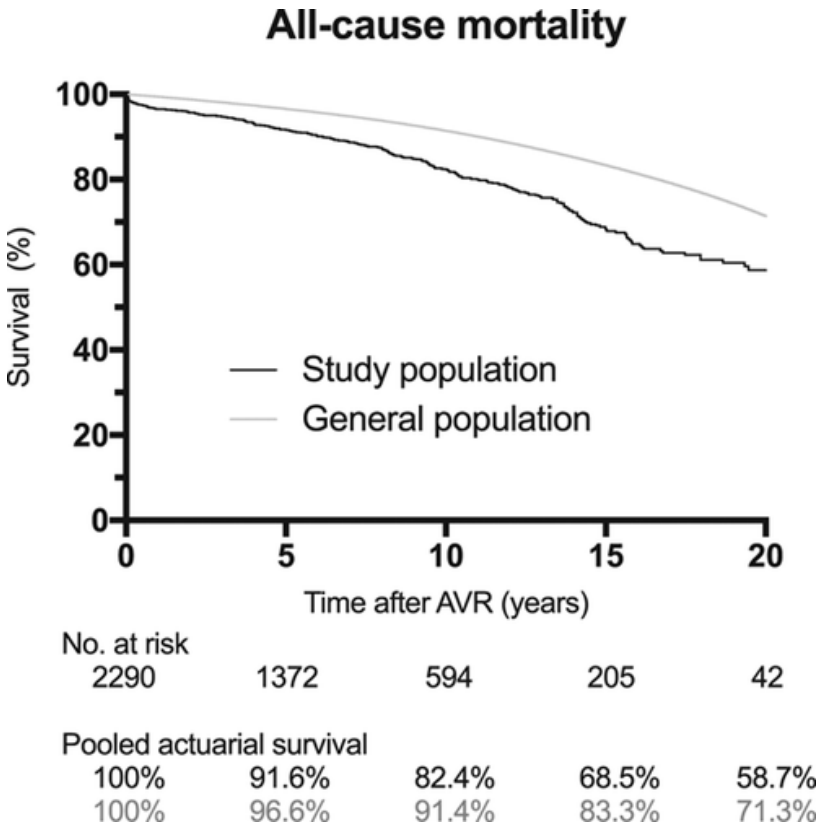
Basic Data Concerning Observed and Expected Deaths Based on Data From Follow-Up Years 1 through 15

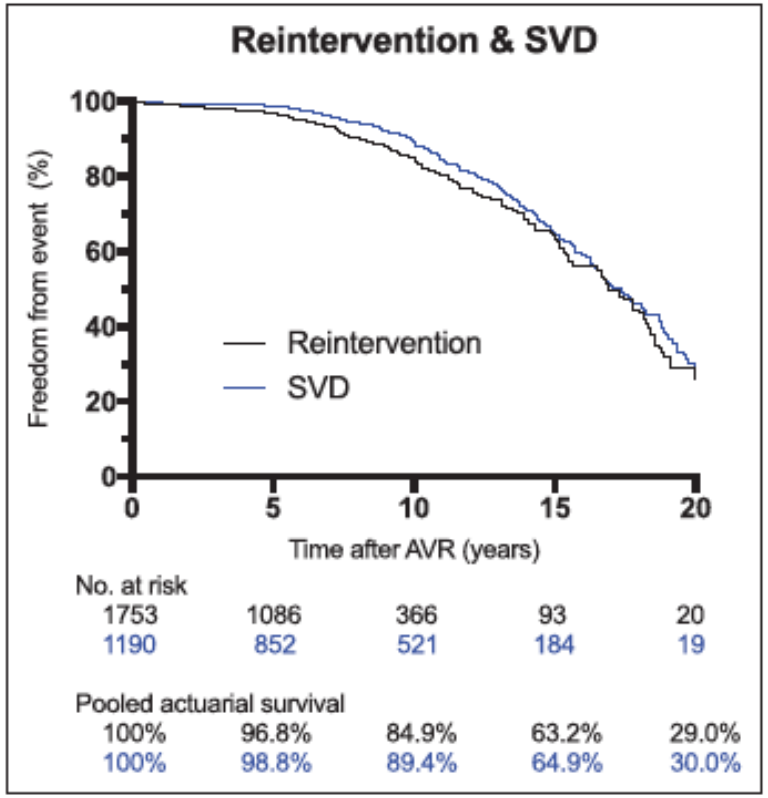
Age (years)	Patient-Years at risk	Observed N of Deaths	Expected N of Deaths	O/E Deaths
≤50	2,182	31	6.8	4.5
51-60	2,954.5	98	36.9	2.7
61-70	5,578.5	274	152.1	1.8
≥71	3,579	212	208.2	1

Kvidal P, et al. J Am Coll Cardiol (2000)

Bioprosthetic Aortic Valve Replacement in Nonelderly Adults

A Systematic Review, Meta-Analysis, and Microsimulation





Jonathan R.G. Etnel. Circulation: Cardiovascular Quality and Outcomes. Bioprosthetic Aortic Valve Replacement in Nonelderly Adults, Volume: 12, Issue: 2, DOI: (10.1161/CIRCOUTCOMES.118.005481)

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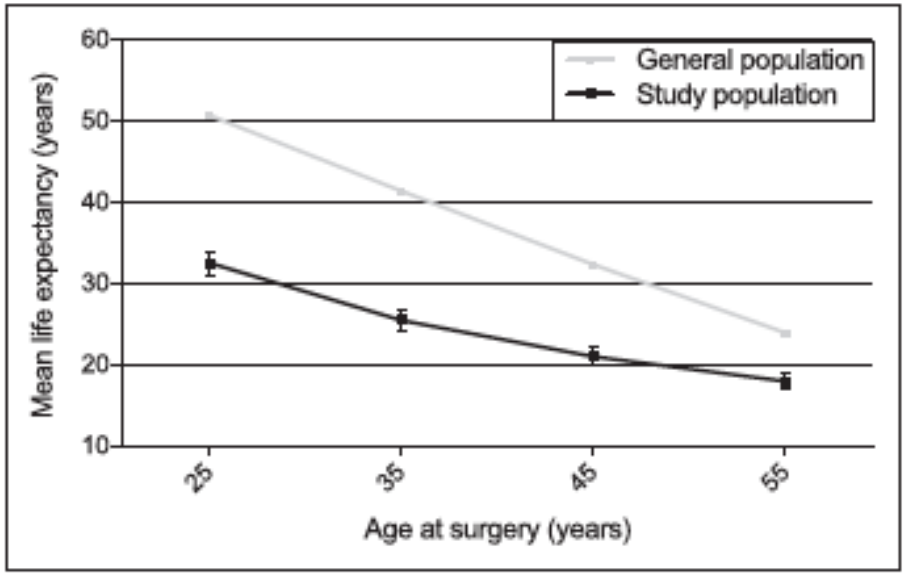


Figure 7. Microsimulation-based age-specific mean life expectancy after bioprosthetic AVR compared with the age- and sex-matched general population.

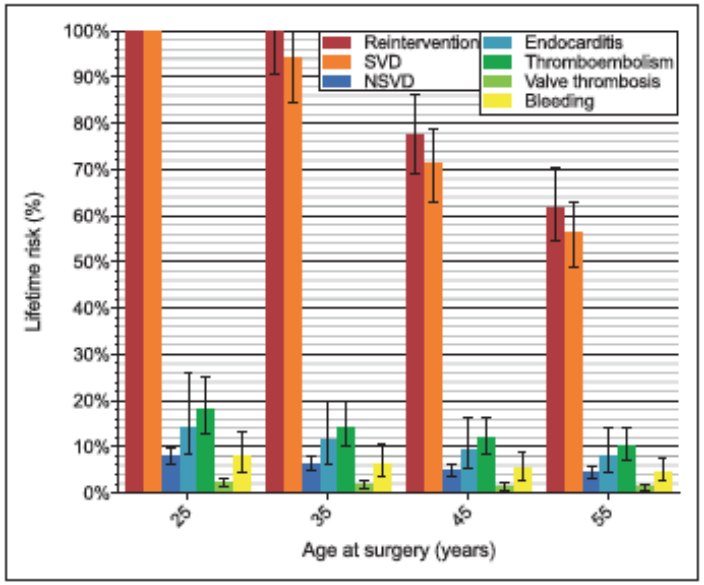
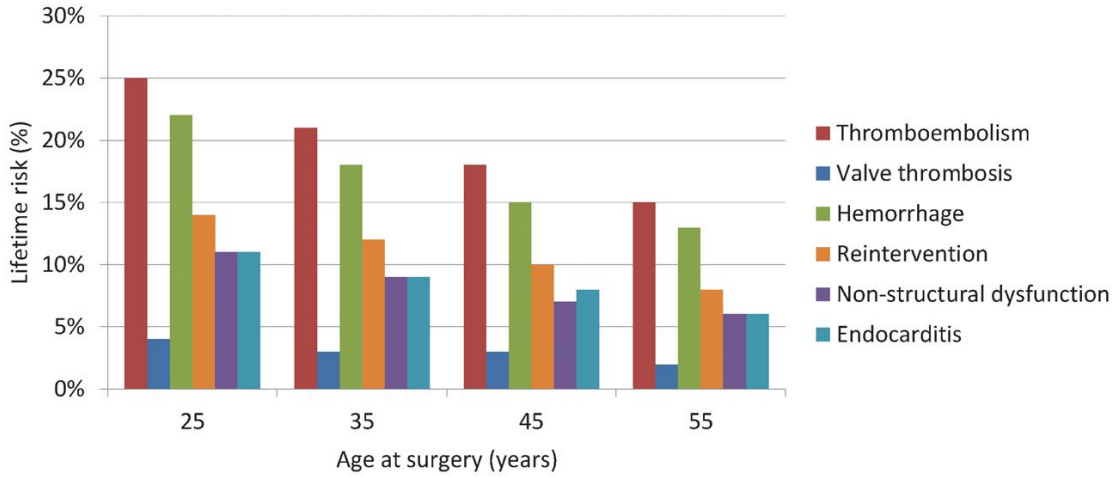


Figure 6. Microsimulation-based age-specific lifetime risks of valve-related morbidity bioprosthetic aortic valve replacement (AVR).
Error bars represent 95% credible intervals. NSVD indicates non-SVD; and SVD, structural valve deterioration.

Jonathan R.G. Etnel. Circulation: Cardiovascular Quality and Outcomes. Bioprosthetic Aortic Valve Replacement in Nonelderly Adults, Volume: 12, Issue: 2, DOI: (10.1161/CIRCOUTCOMES.118.005481)

Mechanical aortic valve replacement in non-elderly adults: meta-analysis and microsimulation



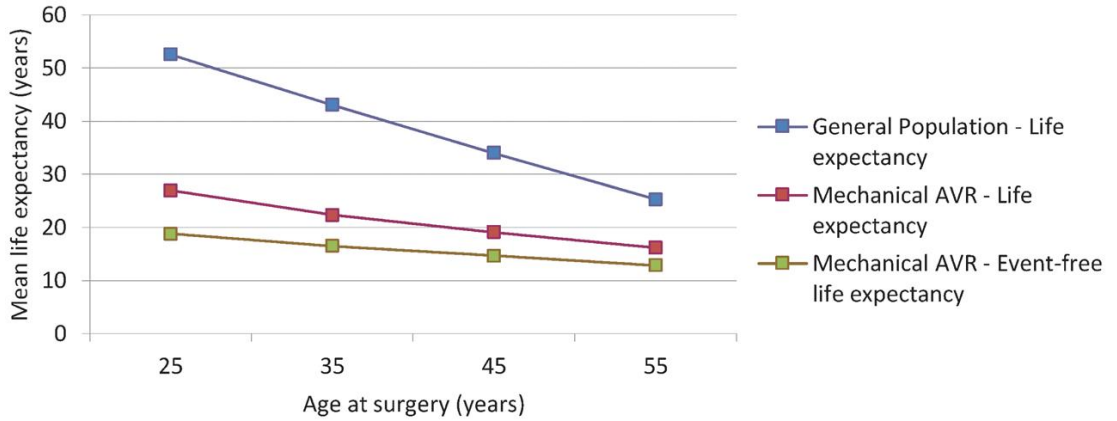
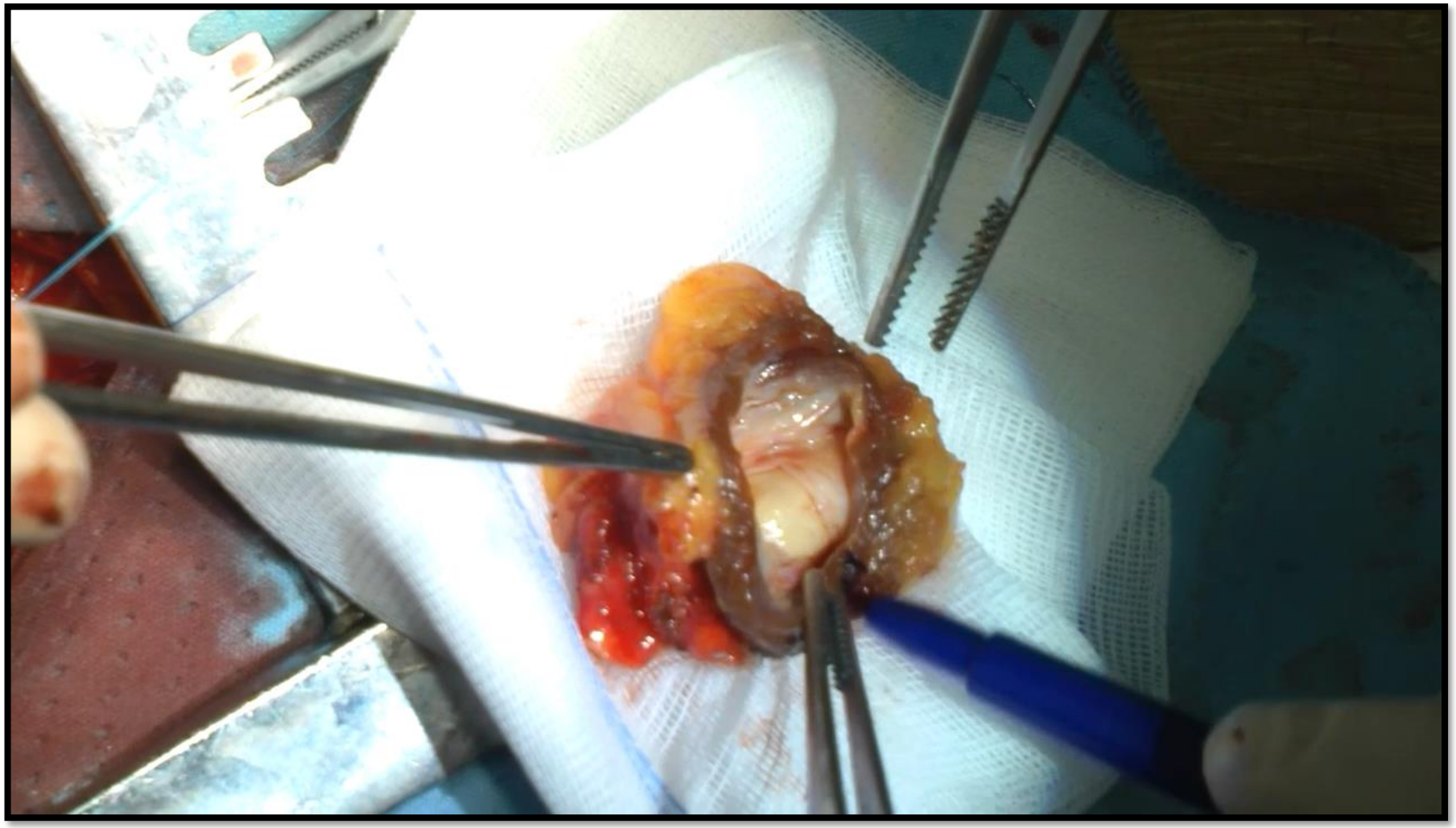


Figure 2 Microsimulation-based age-specific life expectancy and lifetime risk of valve-related morbidity. AVR, aortic ...

European Heart Journal, Volume 38, Issue 45, 01 December 2017, Pages 3370–3377, https://doi.org/10.1093/eurheartj/ehx199

Ross Procedure: pulmonary autograft to replace AV

No OAC, Excellent hemodynamic performance, No endocarditis



The Ross Procedure guarantees long-term viability of the Aortic Valve/Root

Unique **biology** and **hemodynamics.** Thus, **improved** clinically-relevant **outcomes**

TABLE 1 Summary of Contemporary Series Reporting Long-Term Outcomes (≥15 Years) of the Ross Procedure in Adults

First Author (Year) (Ref. #)	Design	Patients, n	Mean Age, yrs	BAV, %	Pure AI/ Mixed AS-AI, %/%	Mean Follow-Up, yrs	Operative Mortality, %	10-yr Survival, %	15-yr Survival, %	20-yr Survival, %	10-yr Freedom From Reintervention, %*	15-yr Freedom From Reintervention, %*	20-yr Freedom From Reintervention, %*
El-Hamamsy et al. (2010) (9)	RCT	108	38	49	45/27	10.2	0.9	97	95†	–	95	94	–
David et al. (2014) (29)	Single-center	212	34	72	36/13	13.8‡	0.4	98	94	94‡	AG 97 HG 98	AG 93 HG 96	AG 82 HG 93
Da Costa et al. (2014) (101)	Single-center	414	31	50	39/31	8.2	2.7	92	89†	–	90	81	–
Andreas et al. (2014) (100)	Single-center	246	29	75	40/31	10.0‡	1.6	95	91†	–	88	81	–
Skillington et al. (2015) (33)	Single-center	322	39	92	32/22	9.8	0.3	98	97	97†	94	93	–
Mastrobuoni et al. (2016) (31)	Single-center	306	42	59	31/0	10.6‡	2.3	97	88	–	–	75	–
Sievers et al. (2016) (32)	Multicenter (prospective)	1,779	45	65	22/52	8.3	1.1	96	90†	–	91	83	–
Martin et al. (2017) (30)	Single-center	310	41	73	19/7	15.1‡	1.3	94	92	84	93	86	70
Sievers et al. (2018) (128)	Single-center	630	45	78	24/–	12.5‡	0.3	95	87	73†	AG 96 HG 97	AG 94 HG 94	AG 90 HG 91

*Includes any reintervention on the pulmonary autograft and/or pulmonary homograft. †Survival equivalent to age- and sex-matched general population. ‡Median (rather than mean) follow-up.
AG = autograft; AI = aortic insufficiency; AS = aortic stenosis; BAV = bicuspid aortic valve; HG = homograft; RCT = randomized controlled trial.

Latest evidence

Mandatory California and New York databases

Young adult patients (18-50 yrs) who underwent Ross procedure or AVR with biological or mechanical prostheses (1997-2014)

Propensity matching (1:1:1) was used, resulting in 434 patients per group

Primary endpoint: **all-cause mortality**

TABLE 1 Patient Characteristics After Propensity Matching for Patients Undergoing a Ross Procedure, Biological AVR, and Mechanical AVR

	Ross Procedure (n = 434)	Bioprosthetic AVR (n = 434)	Mechanical AVR (n = 434)
Age, y	35.9 ± 9.2	36.2 ± 9.4	36.7 ± 8.8
Sex	324 (75)	315 (73)	337 (78)
Race			
White	322 (74)	309 (71)	306 (71)
Black	21 (5)	15 (4)	24 (6)
Other	91 (21)	110 (25)	104 (24)
Hypertension	80 (18)	79 (18)	81 (19)
Atrial fibrillation	16 (4)	15 (4)	14 (3)
Congestive heart failure	65 (15)	65 (15)	62 (14)
Complicated DM	1 (0.2)	1 (0.2)	0 (0)
CKD (non-HD)	2 (0.5)	2 (0.5)	1 (0.2)
COPD	21 (5)	16 (4)	14 (3)
Liver disease	4 (1)	4 (1)	5 (1)
History of cancer	4 (1)	8 (2)	3 (1)
Mean AVR volumes	156 ± 93	157 ± 112	160 ± 117
NY residents	182 (42)	186 (43)	196 (45)
Median hospital LOS, d	5	5	6

Values are mean ± SD, n (%), or median.

AVR = aortic valve replacement; CKD = chronic kidney disease; COPD = chronic obstructive pulmonary disease; DM = diabetes mellitus; HD = hemodialysis; LOS = length of stay; NY = New York.

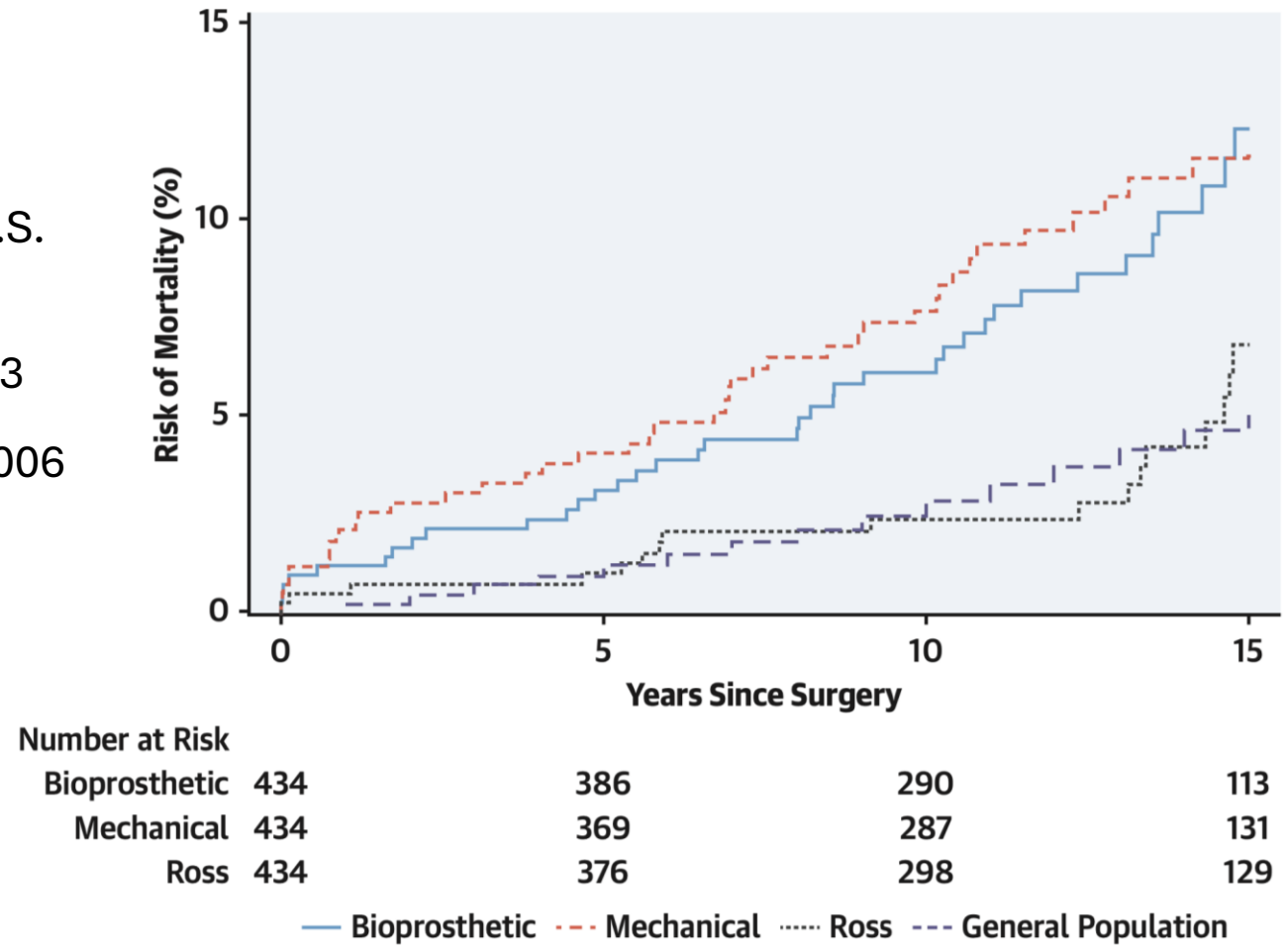
El-Hamamsy I, et al. J Am Coll Cardiol (2022)

15-year survival after Ross → 93.1% [89.1-95.7]

- similar to that of the age-, sex-, and race-matched U.S. general population

Ross vs biological AVR → HR: 0.42 [0.23-0.08], p=0.003

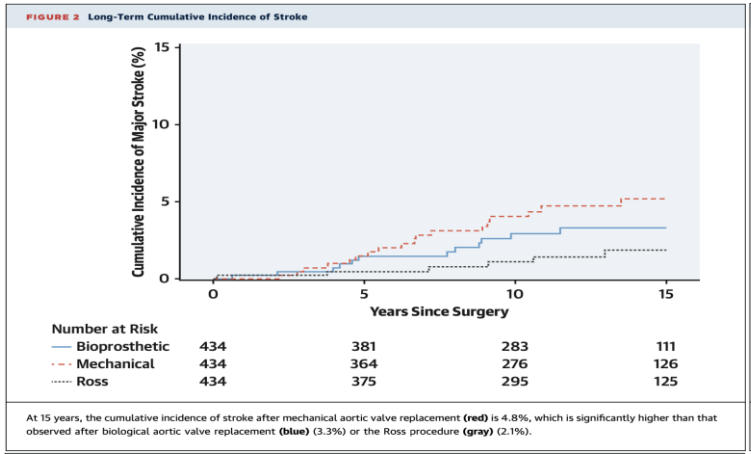
Ross vs mechanical AVR → HR: 0.45 [0.26-0.79], p=0.006

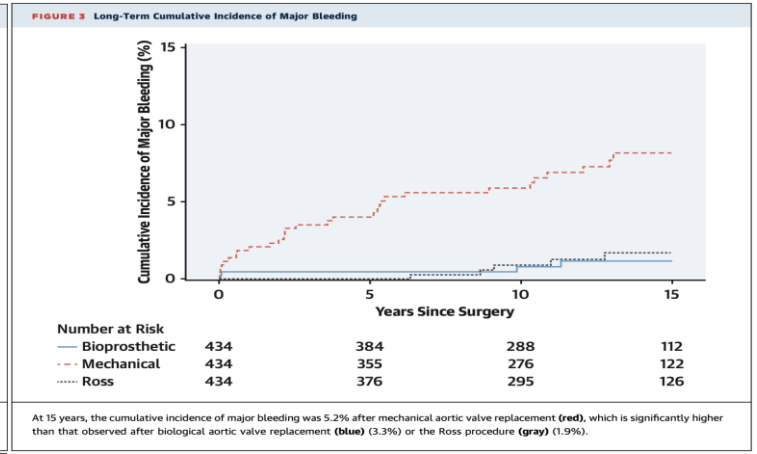


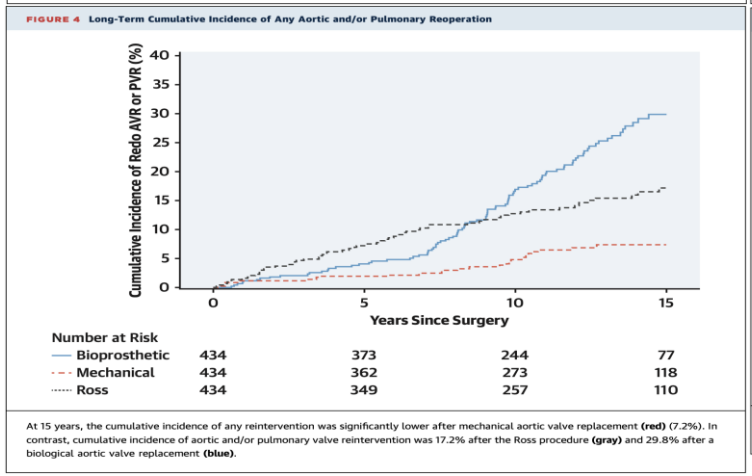
El-Hamamsy I, et al. J Am Coll Cardiol (2022)

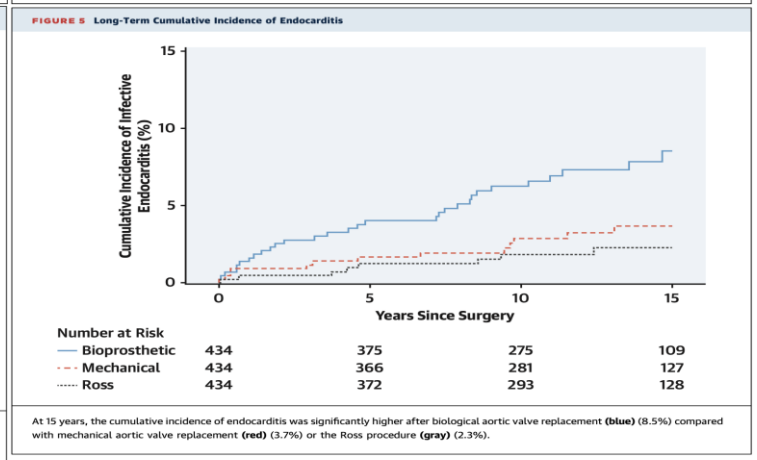
15-year cumulative **reintervention** risk was lower in Ross vs biological AVR (p=0.008), as well as **endocarditis** (p=0.01)

15-year cumulative **reintervention** risk was higher in Ross vs mechanical AVR (p<0.001), but with lower risk of **stroke** (p=0.03) and major **bleeding** (0.016)









El-Hamamsy I, et al. J Am Coll Cardiol (2012)

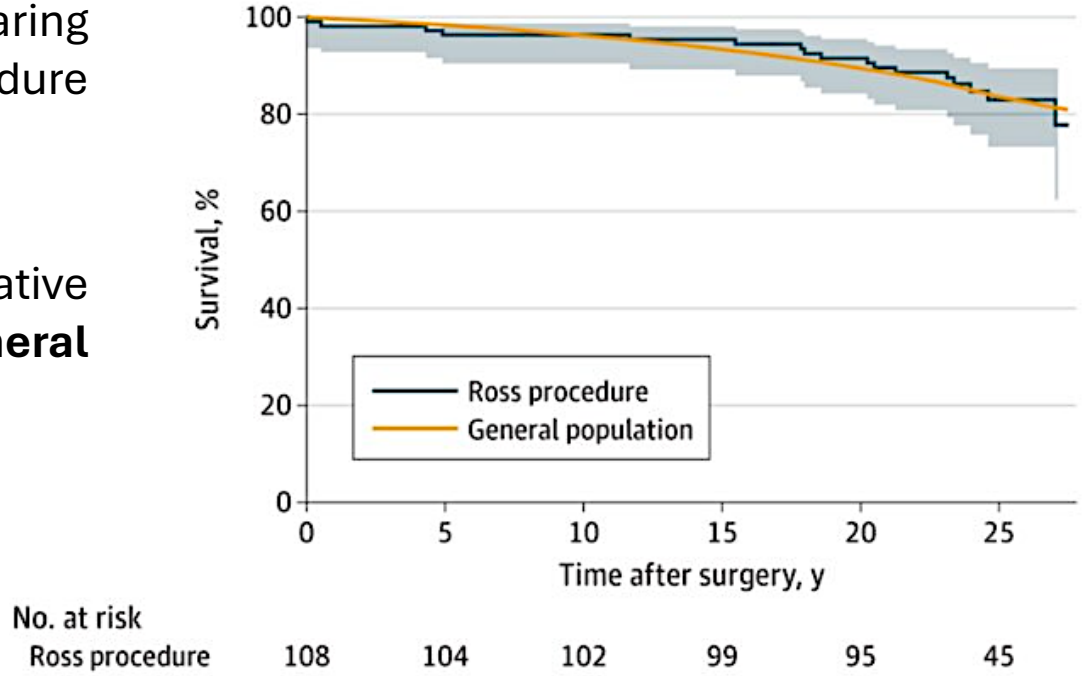
The Longest Reported Outcomes of the Ross Procedure

Post hoc analysis from a single-center RCT comparing homograft root replacement (N=108) with the Ross procedure (N=108) among 216 adults <69 yrs (1994-2001)

Median follow-up: 24.1 yrs [22.6-26.1]; 98% complete

25-year survival was 83.0% [75.5-91.2], representing relative survival of **99.1% [91.8-100] compared to the general population**

25-year freedom from any reintervention was 71.1%



Notenboom ML, El-Hamamsy I, Yacoub MG, et al. JAMA Cardiol (2024)

Ross procedure is the only operation that restores long-term survival following AVR

Is it reproducible?

Preoperative data	Unit	
Cohort	N	37 (100)
Age	Years	38 [22-52]
Female sex	N	12
Body mass index	Kg/m^2	26.3 ± 4.2
EuroSCORE II	%	2.5 [1.7-2.8]
NYHA class III-IV	N	30 (81.1)
LVEF	%	55 [55-60]
Risk Factors	N	
Arterial hypertension		12 (32.4)
Dislipidemia		10 (27.0)
CAD		3 (8.1)
Diabetes		2 (5.4)
Renal insufficiency		3 (8.1)
Renal replacement therapy		1 (2.7)
Atrial Fibrillation		1 (2.7)
Pacemaker/ICD		0 (0.0)
Previous cardiac surgery		1 (2.7)
Endocarditis	N	4 (10.8)

Echocardiographic data	Unit	
AV regurgitation: None-Mild	N	14 (37.8)
AV regurgitation: Severe	N	23 (62.2)
AV stenosis: None-Mild	N	17 (45.9)
AV stenosis: Moderate	N	1 (2.7)
AV stenosis: Severe	N	19 (51.4)
AV Peak Gradient	mmHg	81 [75-89]
AV Mean Gradient	mmHg	47 ± 11
Bicuspid AV	N	24 (64.9)
Unicuspid AV	N	2 (5.4)
AV Annulus Diameter	mm	30.1 ± 5.7
Sinuses of Valsalva Diameter	mm	35.1 ± 5.4
Ascending Aorta Diameter	mm	34.1 ± 5.1
PV Annulus Diameter	mm	25.0 [25.0-27.0]
Common PA Diameter	mm	27.0 [24.5-28.0]
Echo-assessed PAPs	mmHg	25.0 [22.5-29.5]
Imaging	N	
TOE		11 (29.7)
CT scan		24 (64.9)

Intraoperative data	Unit	
Arterial cannulation: ascending Aorta	N	37 (100)
Venous cannulation: Bicaval	N	36 (97.3)
Venous cannulation: Atrio-caval	N	1 (2.7)
Cardiopulmonary bypass time	Min	179.5 ± 25.8
Cross-clamp time	Min	152.5 ± 21.4
Blood Cardioplegia	N	5 (13.5)
Custodiol Cardioplegia	N	32 (86.5)
Retrograde administration	N	2 (5.4)
Homograft - Quality 4/5	N	5 (13.5)
Homograft - Quality 5/5	N	32 (86.5)
Bail-out	N	
Bioprosthesis		0 (0.0)
Mechanical prostesis		0 (0.0)
Combined procedures	N	
Aortic annuloplasty		7 (18.9)
Ascending aorta replacement		9 (24.3)
Other procedures	N	6 (16.2)
CABG		4 (10.8)
Mitral valve repair		1 (2.7)
Removal of subvalvular aortic formation		1 (2.7)

Postoperative data	Unit	
30-day mortality	N	1 (2.7)
MV duration	Hours	8 [6-15]
ICU stay	Hours	38 [24-48]
Total postoperative stay	Days	6 [6-8]
Bleeding requiring re-exploration	N	3 (8.1)
PMI	N	0 (0.0)
CVE	N	0 (0.0)
Renal replacement therapy	N	2 (5.4)
MCS	N	1 (2.7)
Sepsis	N	2 (5.4)
POAF	N	4 (10.8)
Wound infection	N	0 (0.0)
RBC transfusion	N	11 (29.7)
Lab data – Cardiac Troponin I	ng/L	
POD1		19.1 ± 8.5
POD2		7.6 [6.5-12.2]
POD3		3.6 [2.9-9.2]
Concentration AUC		15.2 [12.7-24.7]

Follow Up data	Unit	
Max FU	Months	60
Median FU	Months	12 [12-30]
Events	N	
Mortality		0 (0.0)
Re-intervention		0 (0.0)
Hospidalization		1 (2.8)
PCI		1 (2.8)
Thromboembolism		0 (0.0)
Bleeding		0 (0.0)
Autograft defect		0 (0.0)
Homograft defect		0 (0.0)
NYHA Class I	N	36 (100)

Conclusions

Ross procedure PRO

- AVR with biological or mecahnical prosthesis reduces life expectancy in young adults
- Ross procedure is the only operations tha restores normal life expectancy

Ross procedure CON

- Ross procedure is a complex operation, requires dedicated centres and surgeons
- There is limited availability of pulmonary homografts

Guidelines should better recognize the role of Ross procedure for AVR in young adults