Valve-Replacing Aortic Root Replacement: The evolution of Mechanical and Bioprosthetic Surgical Approaches over Four Decades

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Background & Objectives

- The approach to aortic root replacement is multifaceted, complex, patient specific, and has evolved over time
- Tissue-based bioprosthetic approaches can be an alternative to mechanical composite valve graft (CVG), which may reduce need for lifelong anticoagulation typical in mechanical valves
- Our objective was to describe our 32-year experience with aortic root replacement and compare outcomes in mechanical CVG vs. bioprosthetic root

Composite with mechanical valve

VS

Stentless porcine bioroot

Composite with bioprosthetic valve

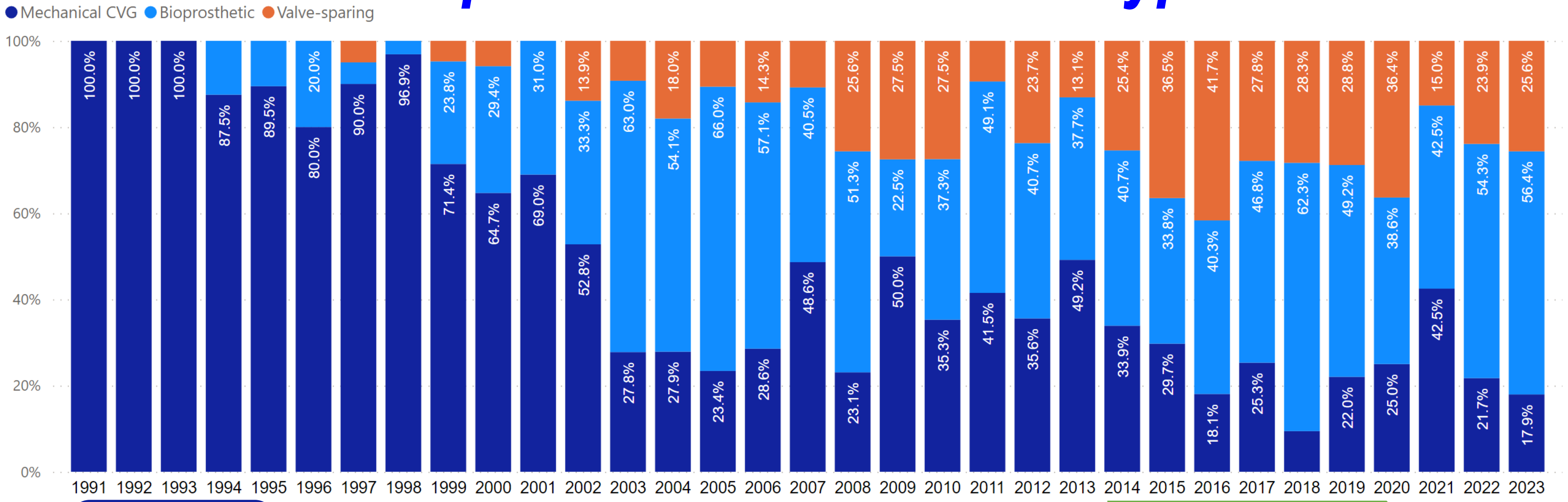
Homograft

Methods

- We retrospectively identified 1149 consecutive patients who underwent aortic root replacement between 1991 and 2023.
  - 581 patients had mechanical CVG
  - 568 patients had bioprosthetic root
    - CVG-tissue = 136
    - Homograft = 98
    - Stentless porcine bioroot = 333
    - Ross = 1
- Data were obtained from a prospectively maintained database and supplemented with a review of additional medical records.

Exclusions
Infection
Acute/subacute dissection
Rupture

Aortic Root Replacement Trends: All types



Exclusively CVG, mechanical

Decreased use of CVG, mechanical

Adoption of homograft

Increased use of Bio-root

Began using TAVR

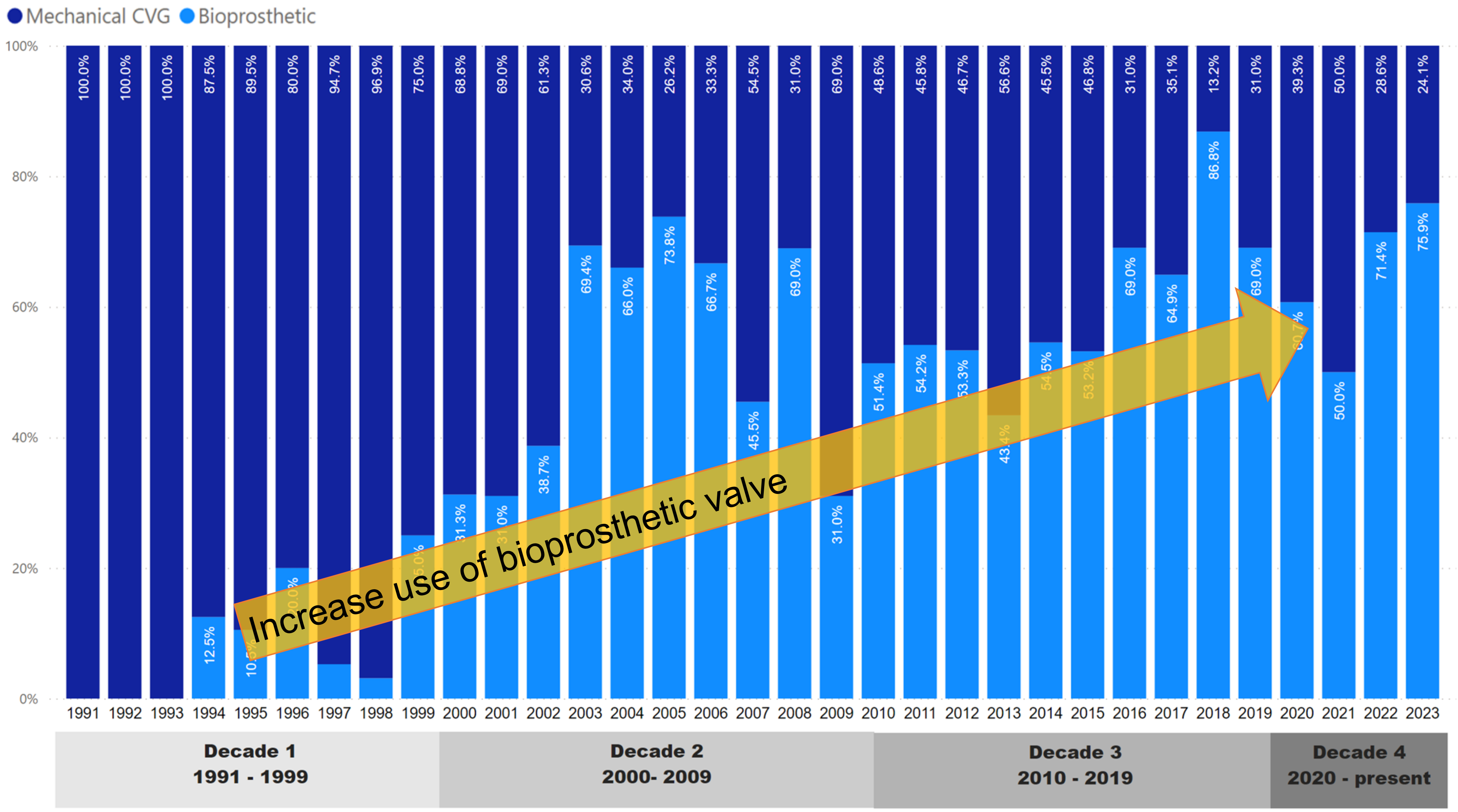
Increase use of CVG, tissue

Increased use of valve-sparing

Decade 1	Decade 2	Decade 3	Decade 4
1991 - 1999	2000- 2009	2010 - 2019	2020 - present

Aortic Root Replacement Trends: Valve-Replacing

- Trends in usage have shifted from our earliest to most recent decade, with the use mechanical CVGs becoming less common over time (from 175/192 [91.1%] in Decade 1 to 100/310 [32.3%] in Decade 4).



Preoperative Characteristics

- In univariate comparison, patients with bioprosthetic roots were older and had higher prevalence of prior open proximal aortic repair, chronic kidney disease, diabetes, HTN, HLD, coronary artery disease, and pulmonary disease
- Interestingly, patients with a mechanical CVG had higher prevalence of genetic disorders, chronic dissection, and a larger proximal aortic max diameter

Variable	Mechanical CVG (n=581)	Bioprosthetic Root (n=568)	*P*
Age (y; median [IQR])	46 [37-56]	60 [49-67]	<.001
Male gender	465 (80)	474 (83.5)	.1
Genetic disorder	178 (30.6)	80 (14.1)	<.001
Prior open proximal aortic repair	131 (22.5)	157 (56.7)	.046
Chronic dissection	93 (16)	66 (11.6)	.03
Proximal aortic max. diameter	5.8 [5.1-6.7]	5.5 [5.0-6.0]	<.001
Chronic kidney disease	57 (9.8)	130 (22.9)	<.001
Symptomatic	372 (64)	389 (68.5)	.1
Diabetes	26 (4.5)	51 (9)	.002
Hypertension (HTN)	371 (63.9)	441 (77.6)	<.001
Hyperlipidemia (HLD)	129 (22.2)	204 (35.9)	<.001
Coronary artery disease	93 (16)	164 (28.9)	<.001
Pulmonary disease	126 (21.7)	176 (31)	<.001

Data are n (%) or median [Q1-Q3]

Operative Details

- Urgent and emergency repair
  - Mechanical: 27.2%
  - Bioprosthetic: 32.6%
- Patients with bioprosthetic roots had longer bypass times, aortic clamp times, and cardiac ischemic time
- Concomitant rates of CABG was higher in patients with bioprosthetic roots
- Between 55-60% of each group have concomitant rate of arch replacement
- Coronary artery reattachment was complicated in redo cases, with reduced use of standard button approach

Variable	Mechanical CVG (n=581)	Bioprosthetic Root (n=568)	*P*
Redo sternotomy	203 (34.9)	221 (38.9)	.16
Total CPB time, min	163 [137-200]	175 [145-216]	.002
Aortic clamp time, min	94 [81-114]	105 [87-133]	<0.001
Cardiac ischemic time, min	110 [92-135]	121 [100-149]	<0.001
Concomitant CABG	61 (10.5)	115 (20.2)	<0.001
IABP insertion	37 (6.4)	71 (12.5)	<0.001
Any arch	329 (56.6)	338 (59.5)	.3
HCA time, min	25 [19-36]	22 [16-31]	.02
Coronary reattachment			
Right button	426 (73.3)	473 (83.3)	<0.001
Left button	394 (67.8)	469 (82.6)	<0.001

Data are n (%) or median [Q1-Q3]

Early Outcomes

- The overall operative mortality was 9.9% (n=1149)
- Mortality rates were influenced by operative complexity
  - Redo sternotomy tended to double the rate of operative mortality
- Patients with a bioprosthetic root had:
  - Higher incidences of permanent renal failure necessitating dialysis
  - Higher rates of cardiac failure
  - Longer overall length of stay in the hospital
- Other early outcomes were similar between groups

Variable	Mechanical CVG (n=581)	Bioprosthetic Root (n=568)	*P*
Operative mortality	50 (8.6)	64 (11.3)	.1
30-day mortality	40 (6.9)	51 (9.0)	.2
Redo sternotomy n = 424	27 (13.3)	40 (18.1)	.2
Index repair	23 (6.1)	24 (6.9)	.7
Persistent stroke	14 (2.4)	6 (1.1)	.08
Permanent renal failure necessitating dialysis	28 (4.8)	57 (10)	<.001
Myocardial infarction	4 (0.7)	5 (0.9)	.7
Cardiac failure	69 (11.9)	115 (20.2)	<.001
Bleeding requiring reop	27 (4.6)	19 (3.3)	.3
ICU length of stay, d	3 [2-6]	3 [2-7]	.08
Overall length of stay, d	10 [8-14]	9 [7-15]	.02

Operative mortality is defined as either in-hospital or 30-day mortality. Permanent complications are those present at time of early death or hospital discharge.
ICU = intensive care unit

Predictors of Operative Mortality

- Overall, operative mortality was significantly higher for redo sternotomies compared to index repairs.
- Infectious complications emerged as a potent mortality concern comparing bioprosthetic versus mechanical valves
- With the introduction of new techniques, the median patient age increased with each subsequent era.
    - The introduction of TAVR in Decade 3 paved the way for advancements in cardiac procedures, enabling surgery on much older patients as compared with previous decades.

Variable	Mechanical CVG (n=581)	Bioprosthetic (n=568)	*P*
Operative mortality	50 (8.6)	64 (11.3)	.1
Redo sternotomy	27 (4.6)	40 (7.0)	.08
Index repair	23 (4.0)	24 (4.2)	.8
Infection	3 (0.5)	21 (3.7)	<.001

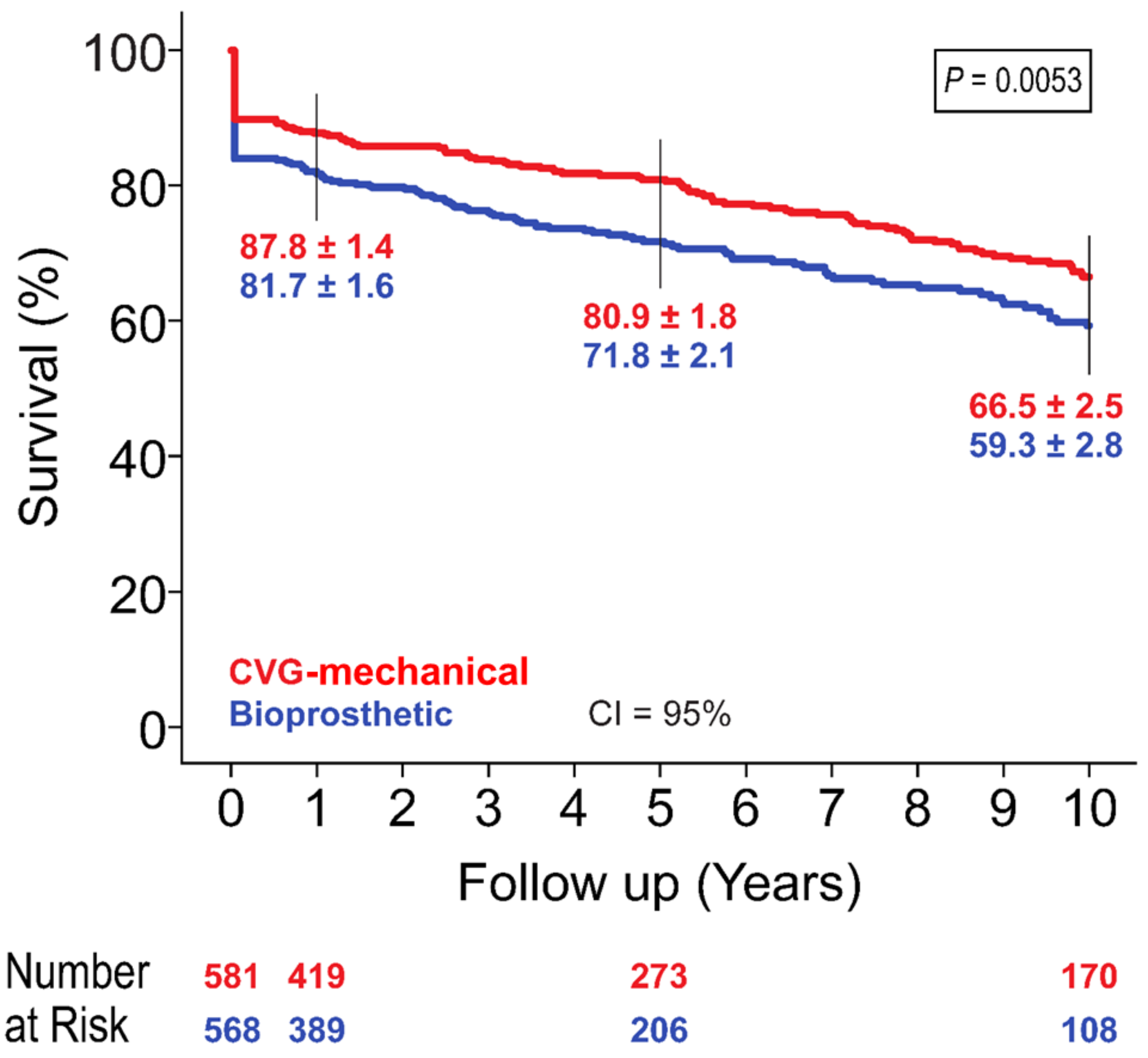
Era of operation	Age, y	Operative mortality
Decade 1 (1990 - 1999)	46 [35-57]	18 (9.4)
Decade 2 (2000 - 2009)	52 [41-62]	33 (9.0)
Decade 3 (2010 - 2019)	55 [43-63]	47 (10.3)
Decade 4 (2020 - Present)	61 [43-69]	16 (12.2)

Survival

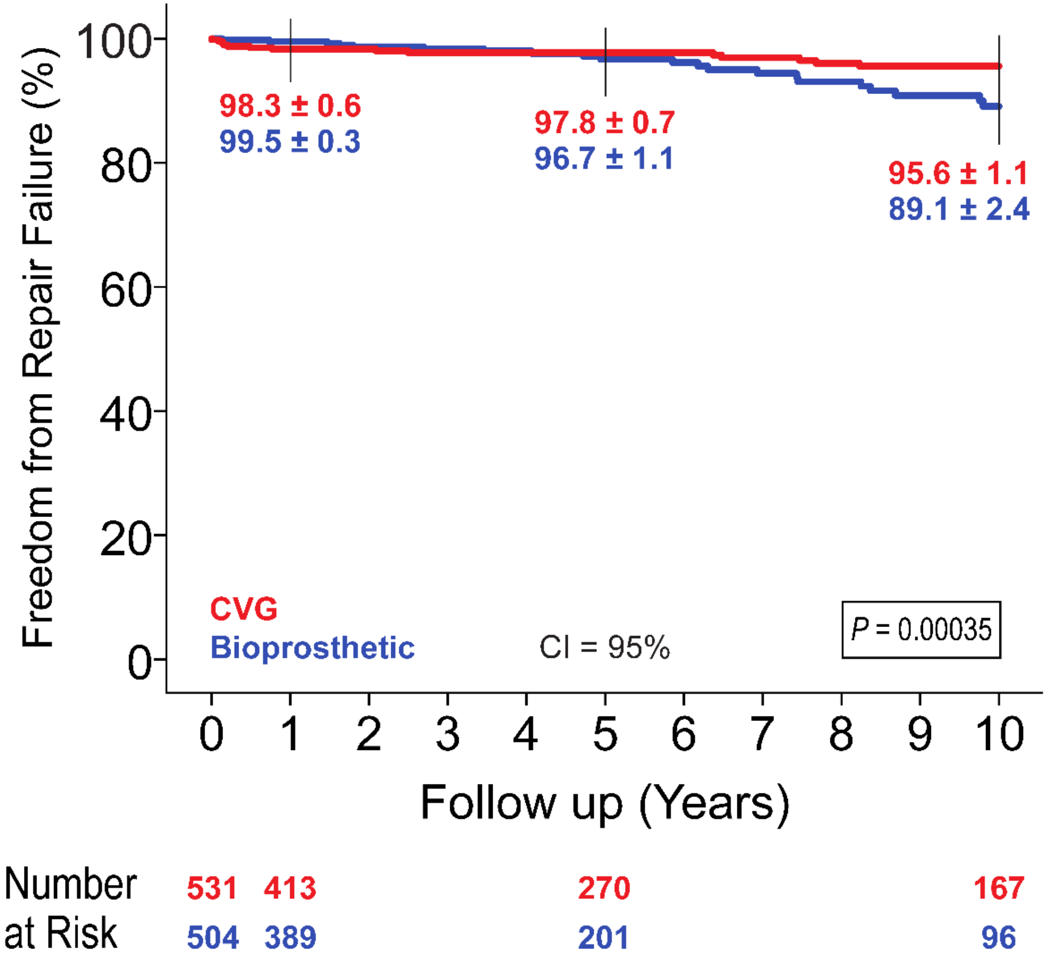
- Unadjusted survival differed between patient who underwent ARR using mechanical and bioprosthetic approaches
- However, this is likely clinically insignificant as there was a significant difference in the age at repair for these patients

Variable	Mechanical CVG (n=581)	Bioprosthetic Root (n=568)	*P*
Age (y; median [IQR])	46 [37-56]	60 [49-67]	<.001

Data are n (%) or median [Q1-Q3]



Late Repair Failure



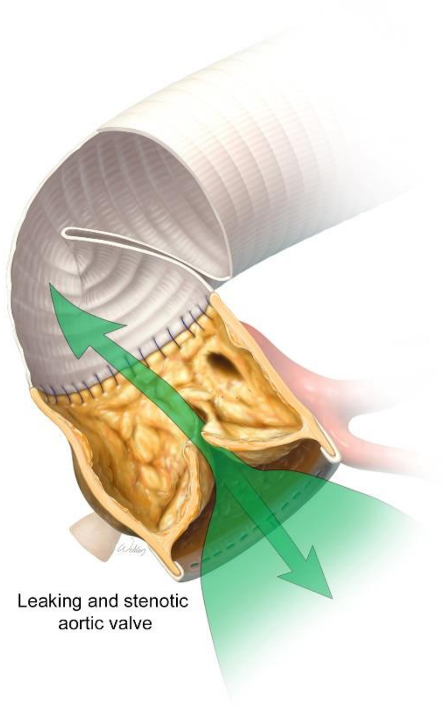
Variable	Mechanical CVG (n=531)	Bioprosthetic Root (n=504)	*P*
Late repair failure	24 (4.1)	34 (6)	.2
Reintervention	22 (3.8)	32 (5.6)	.1
Pseudoaneurysm	9 (1.5)	7 (1.2)	.6
Infection	10 (1.7)	6 (1.1)	.3
Any late valve dysfunction	2 (0.4)	24 (4.8)	<.001
Regurgitation	2 (0.3)	22 (3.9)	<.001
Stenosis	2 (0.3)	8 (1.4)	.052

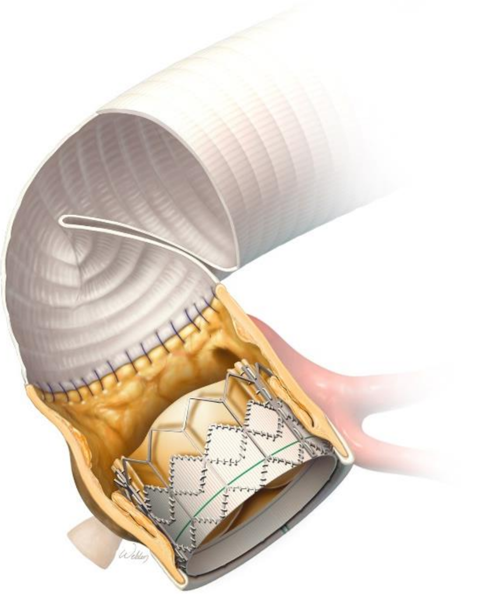
Data are n (%) or median [Q1-Q3]

- Repair failure was uncommon in both groups
- Patients with a bioprosthetic root had higher rates of late valve dysfunction

Conclusions

- Valve selection in ARR remains dependent on patient-specific needs including lifestyle.
- Descriptively evaluating usage trends can inform the selection process
  - Longer intra-operative times with bioprosthetic roots
- Operative mortality is similar between groups, although renal and cardiac complications are greater in patients undergoing bioprosthetic ARR.
  - Over the decades, median age for root replacement has increased suggests surgeons may be more willing to implant bioprosthetic valves in older patients in recent eras given advances like TAVR for reintervention
- Although late aortic regurgitation is more common in bioprosthetic roots, transcatheter repair is increasingly being used to address these concerns





Thank you!