



Surgical Options for Valvular Aortic Stenosis



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Disclosures

- None



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Preamble

- Pediatric Aortic Stenosis, especially in infancy, underscores the primary challenge facing congenital heart surgeons
 - The lack of any growable replacement tissue, especially valves
 - This gap in technology means we have to accept periods of suboptimal physiology because of an imperfect valve with consequences on the ventricle, lungs, etc.
 - Potentially compromising the quality and quantity of life for the patients we serve

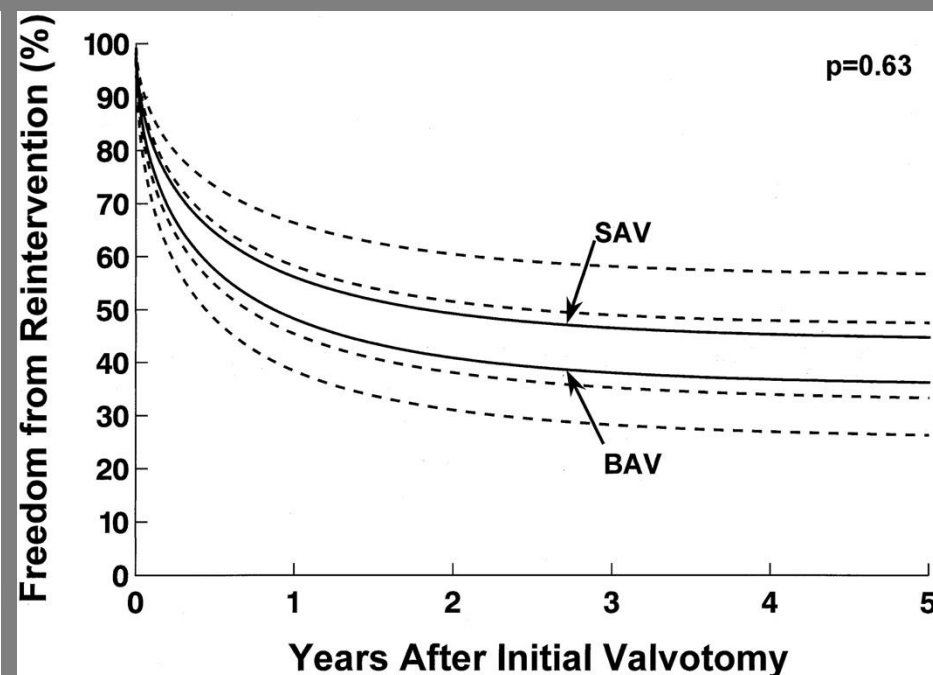
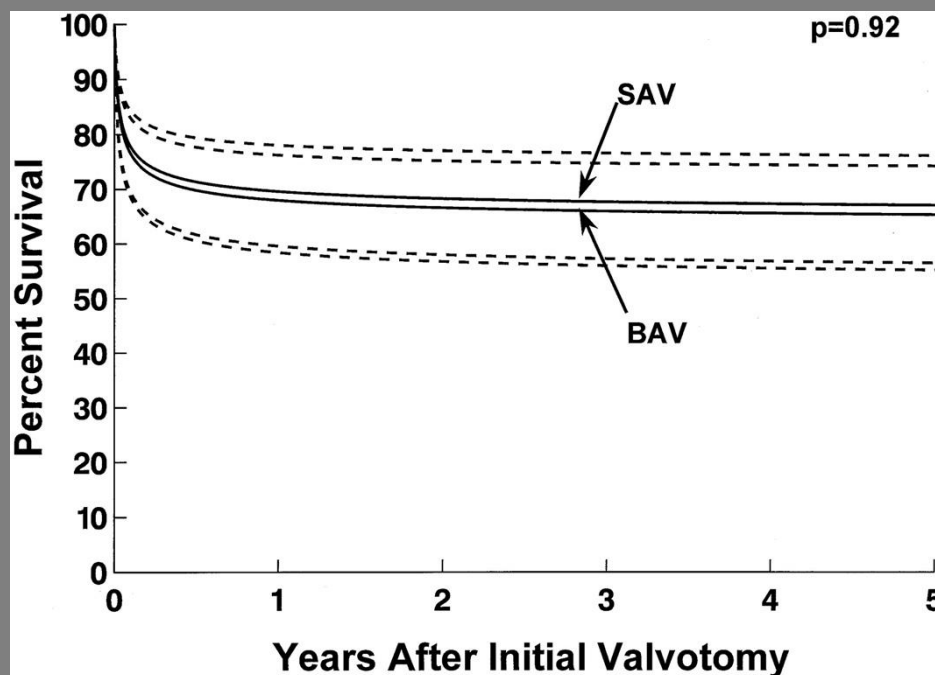
Preamble

- Because of this gap in technology without any off-the-shelf, growable replacement valve options, we often debate what alternative therapies are better
 - Surgical options versus transcatheter options
- But in reality all of these alternative therapies can have a role, given certain patient characteristics
 - Our focus should be on a patient-centric choice

Are Outcomes of Surgical Versus Transcatheter Balloon Valvotomy Equivalent in Neonatal Critical Aortic Stenosis?

Brian W. McCrindle, Eugene H. Blackstone, William G. Williams, Rekwan Sittiwangkul, Thomas L. Spray, Anthony Azakie, Richard A. Jonas and the members of the Congenital Heart Surgeons Society

Circulation. 2001;104:I-152-I-158

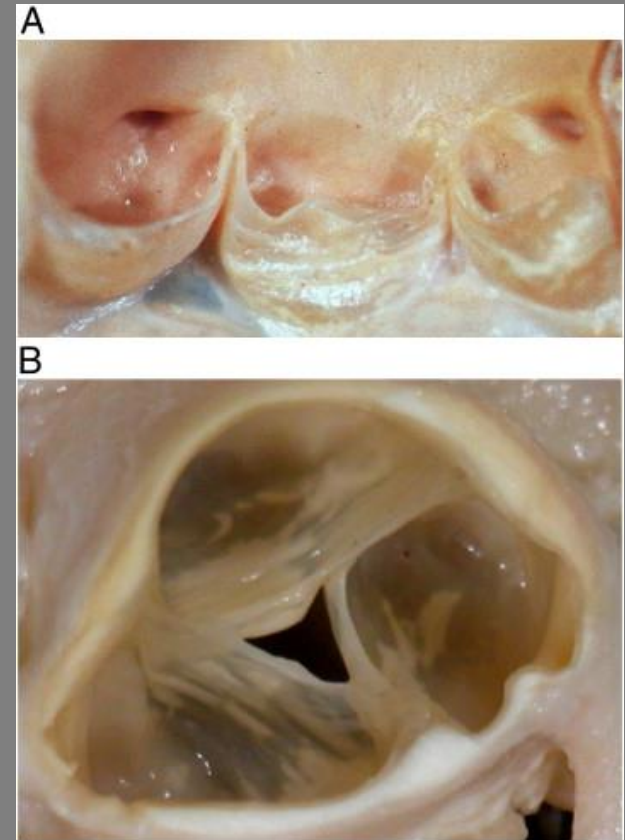
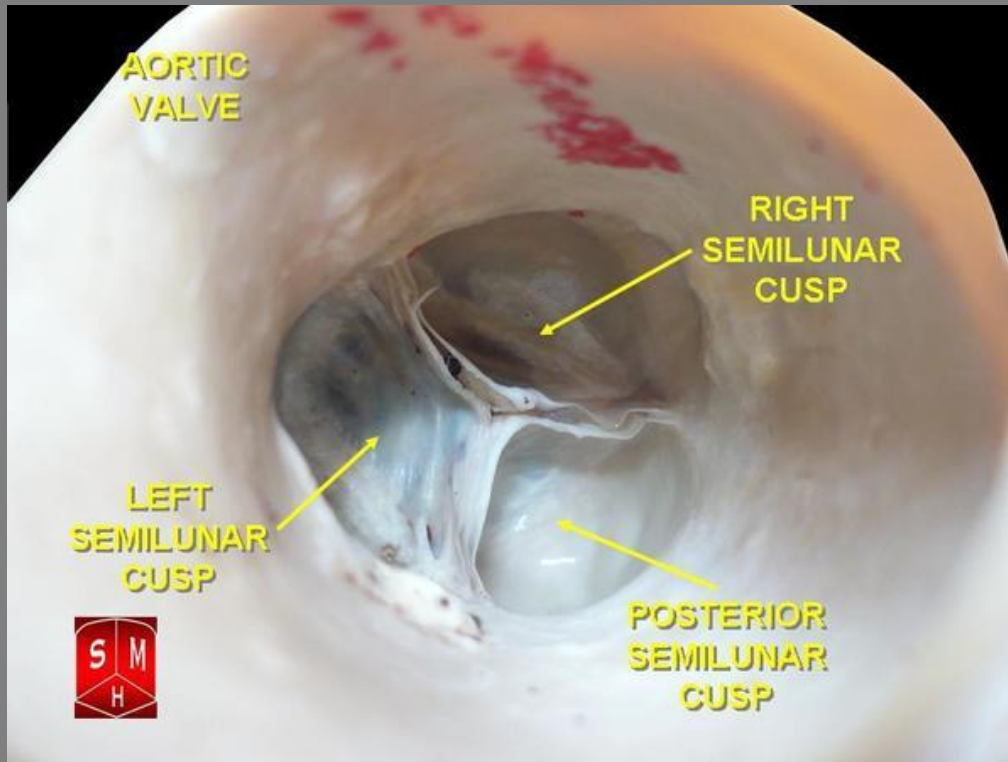


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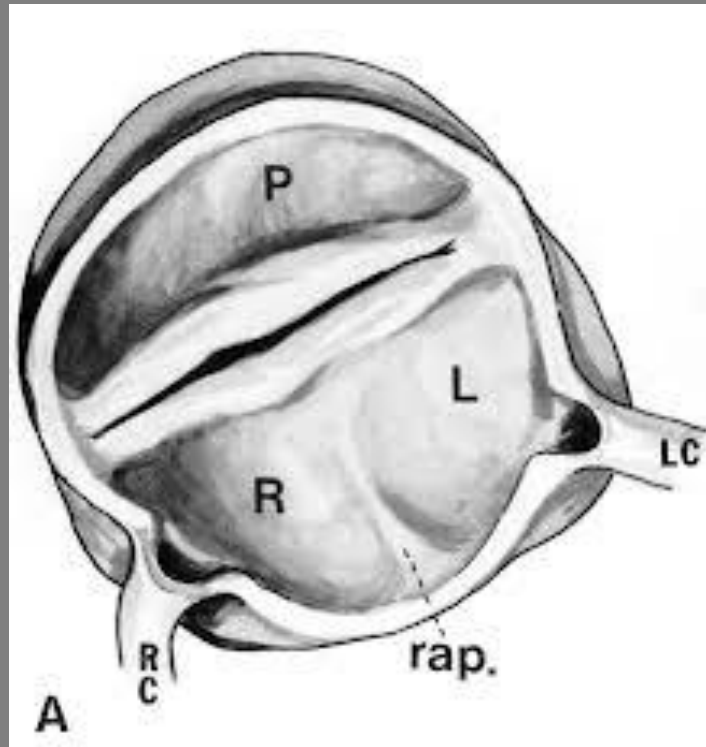
Normal Aortic Valve



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Bicuspid Aortic Valve

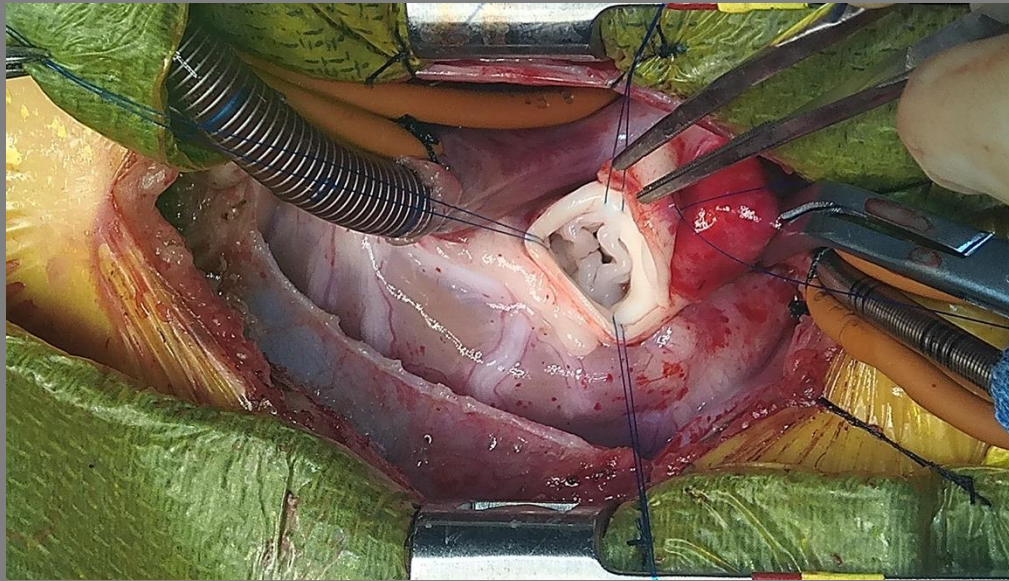
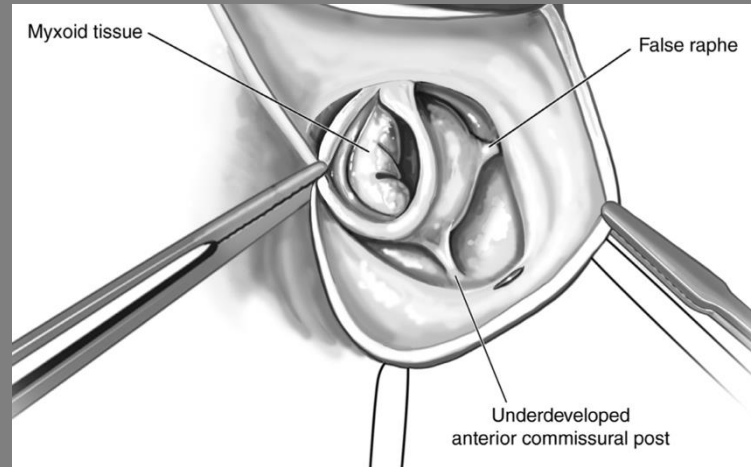


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Unicuspid Aortic Valve



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Balloon Aortic Valvuloplasty

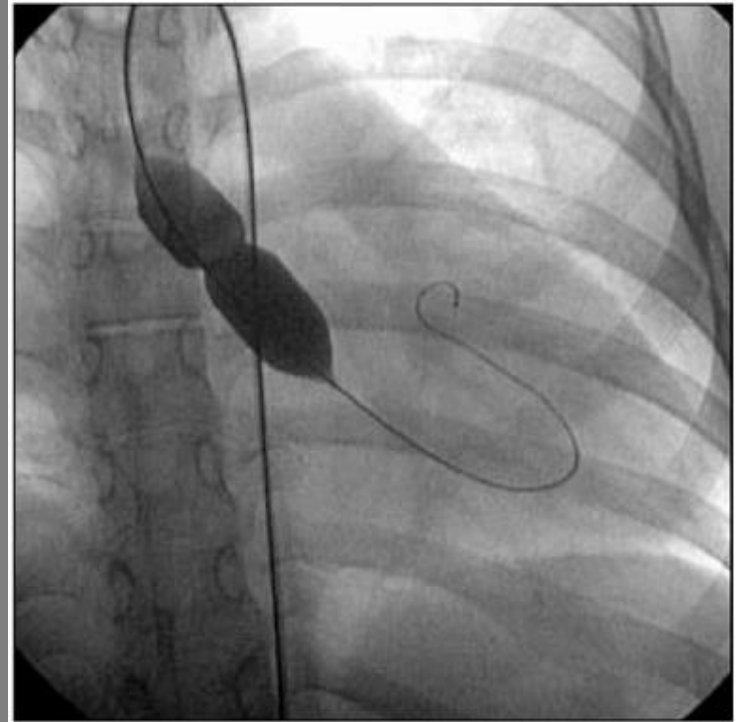
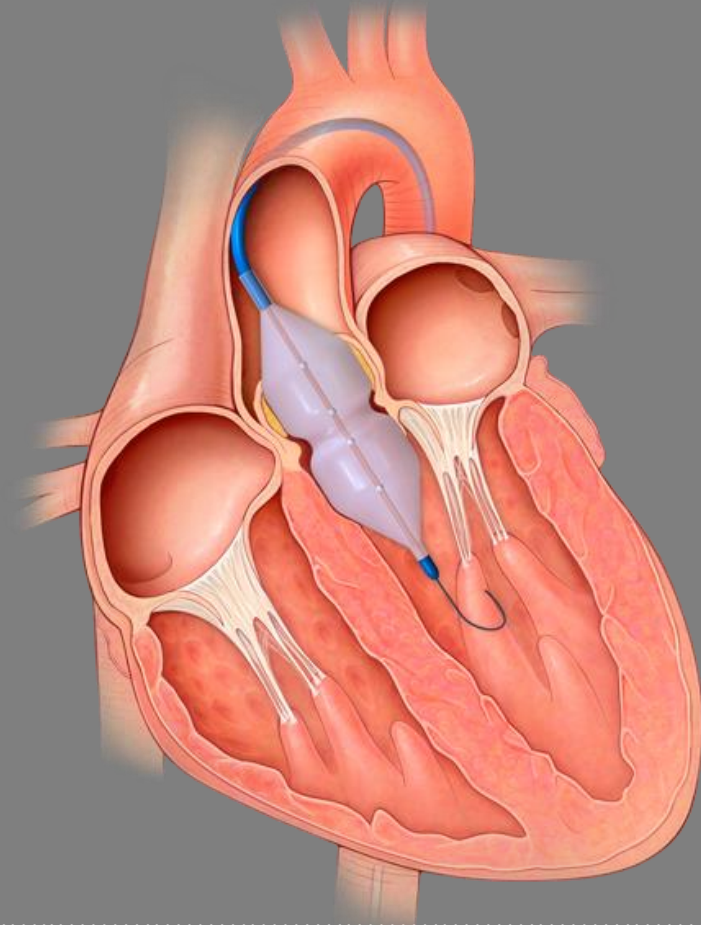


Fig. 3 - Aortogram in right anterior oblique projection. Balloon dilation of the aortic valve. A constriction corresponding to valvular stenosis may be seen.



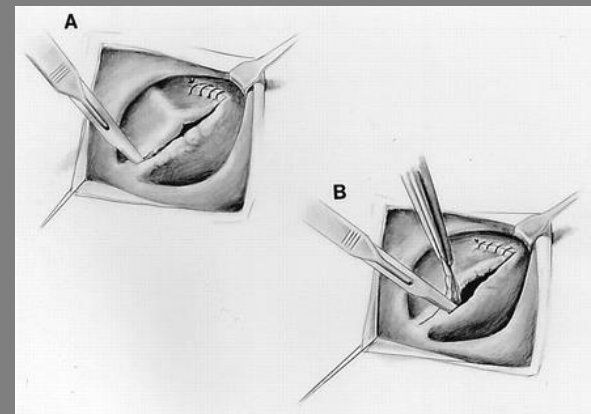
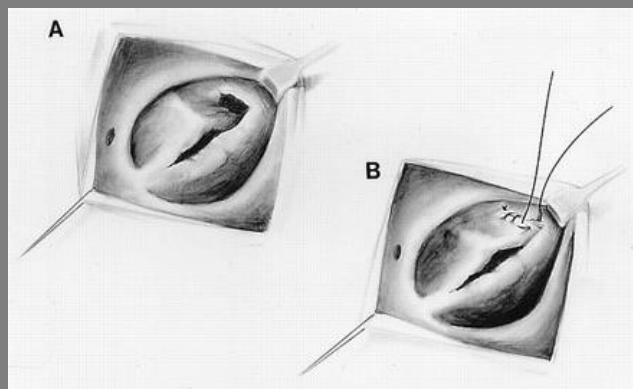
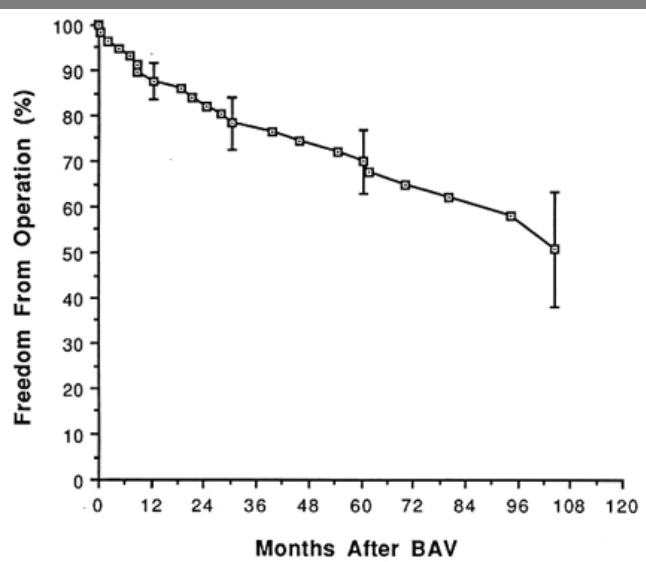
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Aortic Valve Repair and Replacement After Balloon Aortic Valvuloplasty in Children

John A. Hawkins, MD, L. Luann Minich, MD, Robert E. Shaddy, MD, Lloyd Y. Tani, MD, Garth S. Orsmond, MD, Jane E. Sturtevant, BSN, Edwin C. McGough, MD

Division of Cardiothoracic Surgery and Pediatric Cardiology, Departments of Surgery and Pediatrics, University of Utah and Primary Children's Medical Center, Salt Lake City, Utah



Conclusions. Aortic valve operation is required in 5% to 7% of patients yearly after BAV. The need for operation appears to be unrelated to age at the time of BAV; aortic insufficiency predominates over aortic stenosis as an indication for operative intervention. Valve repair can be applied in some patients after BAV with good intermediate-term results and may delay the need for aortic valve replacement.



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IMPACT

Acute Success of Balloon Aortic Valvuloplasty in the Current Era

A National Cardiovascular Data Registry Study



Brian A. Boe, MD,^a Jeffrey D. Zampi, MD,^b Kevin F. Kennedy, MS,^c Natalie Jayaram, MD, MSB,^d Diego Porras, MD,^e Susan R. Foerster, MD,^f Aimee K. Armstrong, MD^a

The patient population was subdivided by diagnosis into either critical AS or noncritical AS. Critical AS was defined by patients who were <1 month of age at the time of the procedure and receiving prostaglandin infusion within 1 day of the catheterization



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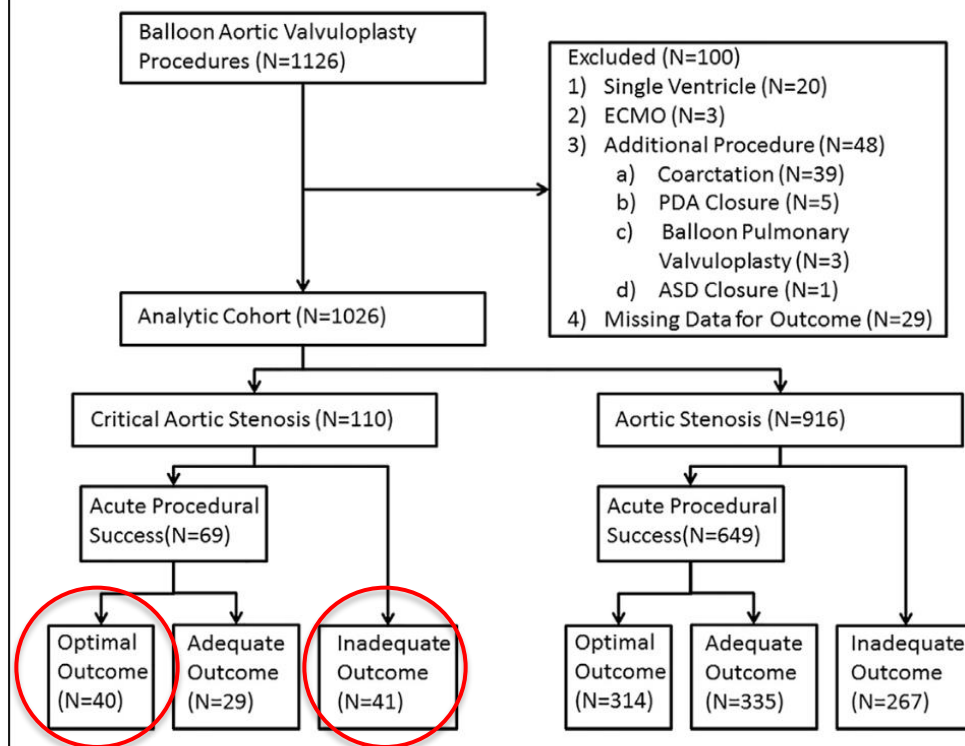
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TABLE 1 Patient Demographics

	All (N = 1,026)	Noncritical Aortic Stenosis (n = 916)	Critical Aortic Stenosis (n = 110)
Male	707 (68.9)	630 (68.8)	77 (70.0)
Age categories			
<1 month	281 (27.4)	171 (18.7)	110 (100.0)
1-11 months	259 (25.2)	259 (28.3)	0 (0.0)
1-5 yrs	102 (9.9)	102 (11.1)	0 (0.0)
6-10 yrs	114 (11.1)	114 (12.5)	0 (0.0)
11-17 yrs	191 (18.6)	191 (20.9)	0 (0.0)
>18 yrs	79 (7.7)	79 (8.6)	0 (0.0)
Weight (kg)	25.0 ± 29.3	27.5 ± 30.0	3.7 ± 2.8
Genetic syndrome	51 (5.0)	47 (5.1)	4 (3.6)
Prior cardiac catheterization	308 (30.2)	307 (33.7)	1 (1.0)
Prior cardiac surgery	214 (21.3)	214 (23.9)	0 (0.0)
Type of disease			
Stenosis	687 (67.0)	595 (65.0)	92 (83.6)
Mixed	339 (33.0)	321 (35.0)	18 (16.4)
Aortic valve diameter (mm)	12.5 ± 6.5	13.2 ± 6.4	6.3 ± 1.1
Valve morphology			
Unicuspid	166 (16.3)	123 (13.5)	43 (39.1)
Bicuspid	701 (68.7)	651 (71.5)	50 (45.5)
Tricuspid	107 (10.5)	98 (10.8)	9 (8.2)
Quadricuspid	1 (0.1)	0 (0.0)	1 (0.9)
Uncertain	45 (4.4)	38 (4.2)	7 (6.4)
Pre-procedural PSEG	59.4 ± 21.9	59.0 ± 21.0	63.5 ± 28.0
Pre-procedural AI			
None	685 (66.9)	593 (64.9)	92 (83.6)
1+	270 (26.4)	253 (27.7)	17 (15.5)
2+	47 (4.6)	47 (5.1)	0 (0.0)
3+	9 (0.9)	9 (1.0)	0 (0.0)
4+	13 (1.3)	12 (1.3)	1 (0.9)

Values are n (%) or mean ± SD.

AI = aortic insufficiency; PSEG = peak systolic ejection gradient.

FIGURE 1 Study Population and Primary Outcomes by Diagnosis

ASD = atrial septal defect; ECMO = extracorporeal membrane oxygenation;
PDA = patent ductus arteriosus.



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TABLE 4 Adverse Events

Severity Level	Adverse Event	Noncritical Aortic Stenosis (n = 916)	Critical Aortic Stenosis (n = 110)	p Value
Minor	Balloon rupture	41 (4.5%)	3 (2.7%)	0.392
Major	Arrhythmia requiring antiarrhythmic medication	14 (1.5%)	4 (3.6%)	0.112
	Major bleeding event*	15 (1.6%)	2 (1.8%)	0.891
	Arrhythmia requiring cardioversion	13 (1.4%)	3 (2.7%)	0.742
	Other vascular complications requiring treatment†	11 (1.2%)	10 (9.1%)	<0.001
	Arrhythmia requiring temporary pacemaker	10 (1.1%)	0 (0.0%)	0.271
	Cardiac arrest	8 (0.9%)	1 (0.9%)	0.971
	Unplanned cardiac surgery†	7 (0.8%)	2 (1.8%)	0.263
	Unplanned vascular surgery†	3 (0.3%)	0 (0%)	0.547
	Airway event requiring intubation	2 (0.2%)	0 (0%)	0.623
	Subsequent cardiac catheterization†	1 (0.1%)	4 (3.6%)	<0.001
	Tamponade‡	1 (0.1%)	3 (2.7%)	<0.001
	Event requiring ECMO†	1 (0.1%)	1 (0.9%)	0.072
	Event requiring LVAD†	1 (0.1%)	0 (0.0%)	0.728
	Embolic stroke§	1 (0.1%)	0 (0.0%)	0.728
	Death	0 (0.0%)	0 (0.0%)	0.999
	Air embolus	0 (0.0%)	0 (0.0%)	0.999
	New requirement for dialysis	0 (0.0%)	0 (0.0%)	0.999
	Arrhythmia requiring permanent pacemaker	0 (0.0%)	0 (0.0%)	0.999
	Unplanned other surgery†	0 (0.0%)	0 (0%)	0.999
	Total adverse events	129 (14.1%)	33 (30.0%)	<0.001
	Major adverse events	88 (9.6%)	30 (27.3%)	<0.001
	In-hospital death	14 (1.5%)	11 (10.0%)	<0.001
	30-day mortality	8 (0.9%)	7 (6.3%)	<0.001

Values are n (%). *Within 72 h of cardiac catheterization and associated with one of the following: 1) hemoglobin decrease of ≥ 3 g/dl; 2) transfusion of whole blood or packed red blood cells; and 3) procedural intervention or surgery at the bleeding site to reverse, stop, or correct the bleeding. †As a result of a catheterization complication. ‡Requiring pericardial drainage. §Within 72 h of cardiac catheterization. ||Occurring in the catheterization laboratory.

ECMO = extracorporeal membrane oxygenation; LVAD = left ventricular assist device.



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Surgical Options

- Valve Repair, repair, repair, repair!
 - Commisurotomy
 - Complex valve repair techniques
- Valve Replacement
 - Mechanical valve
 - Bioprosthetic valve
 - Homograft
- Ross procedure



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Valve Replacement



- Smallest made is 16mm, so not possible in a neonate or infant!



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Homografts



- All sizes, but not durable, early calcification and degeneration. Nearly 100% fail within 2 years

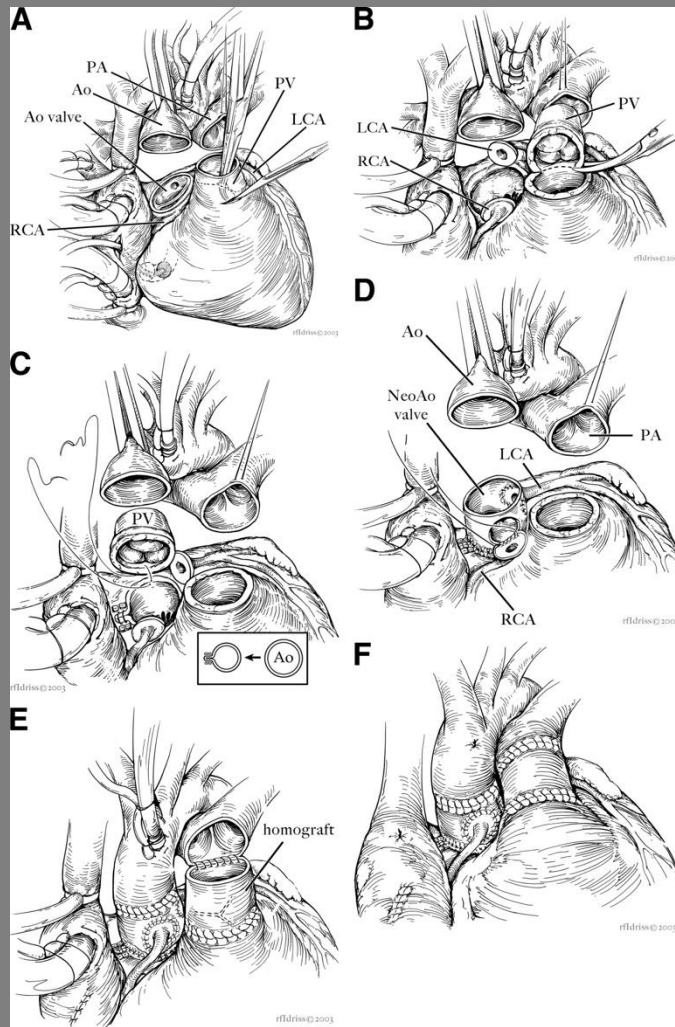


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Ross Procedure



Ross-Konno Procedure

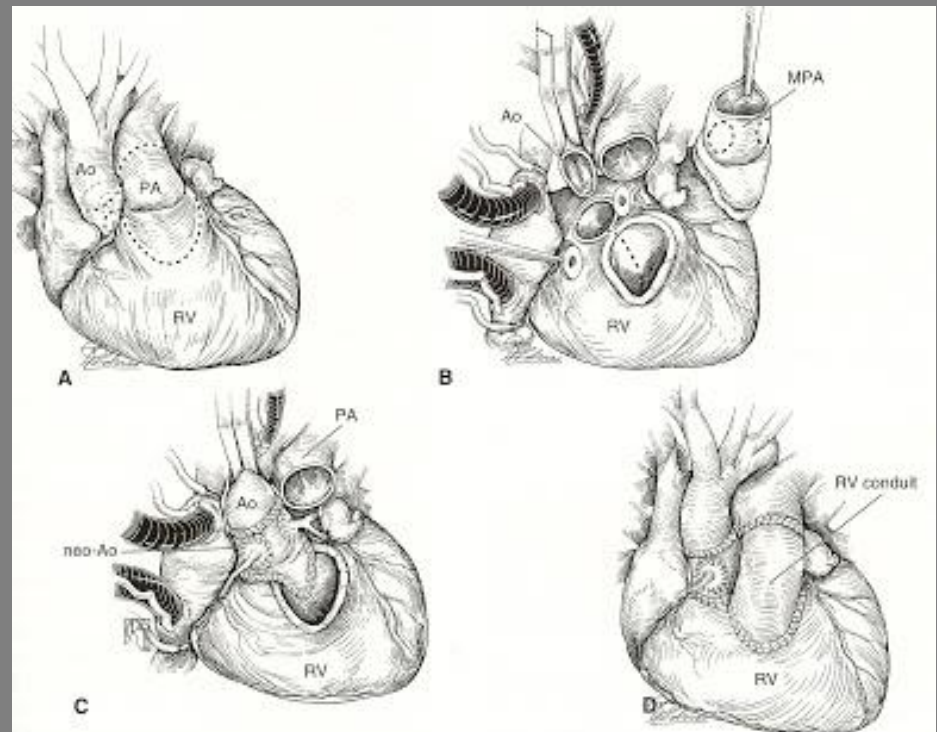


Fig. 29-3 **A**, Intended incision and excision boundaries en route to the Ross-Konno procedure. **B**, After aortic cross-clamping, antegrade and retrograde cardioplegic arrest, aortic resection, coronary mobilization, and main pulmonary artery harvest, the interventricular septal incision is noted by the dotted line. The pulmonary autograft was harvested, with an extra portion of right ventricle to be used for the ventriculoseptoplasty part of this operation. **C**, The neo-aortic left ventricular outflow reconstruction is shown using the pulmonary autograft extension into the interventricular septum. **D**, The completed Ross-Konno procedure is shown after separation from cardiopulmonary bypass. Ao, Aorta, aortic; MPA, main pulmonary artery; PA, pulmonary artery; RV, right ventricle.



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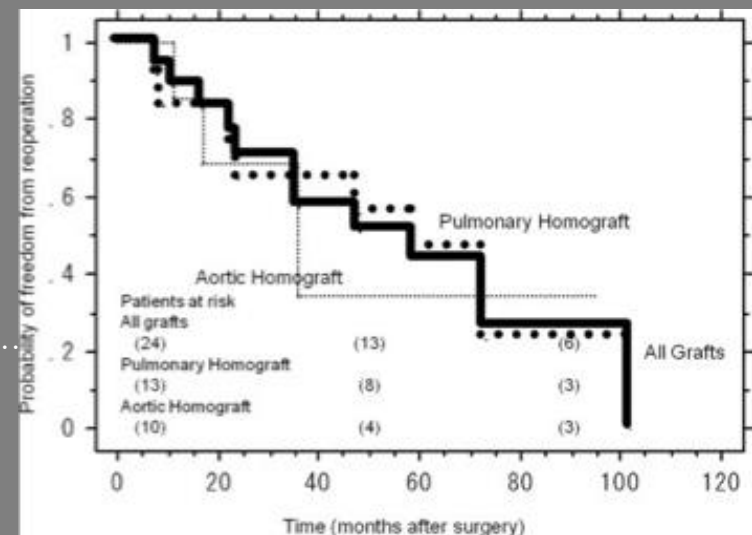
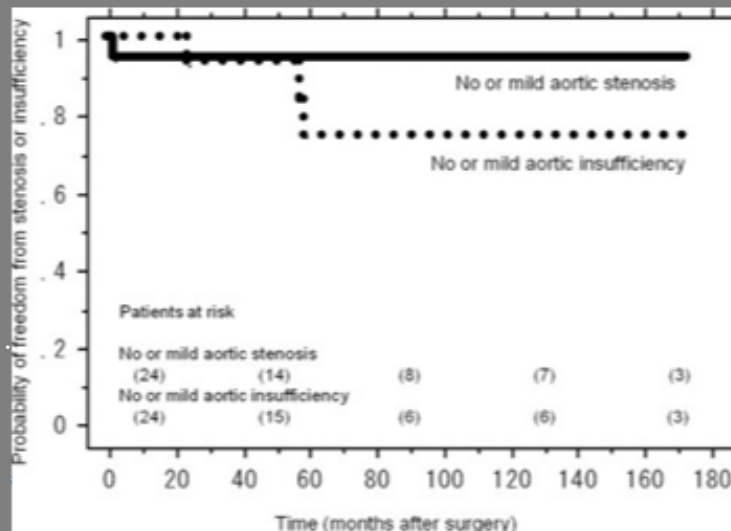
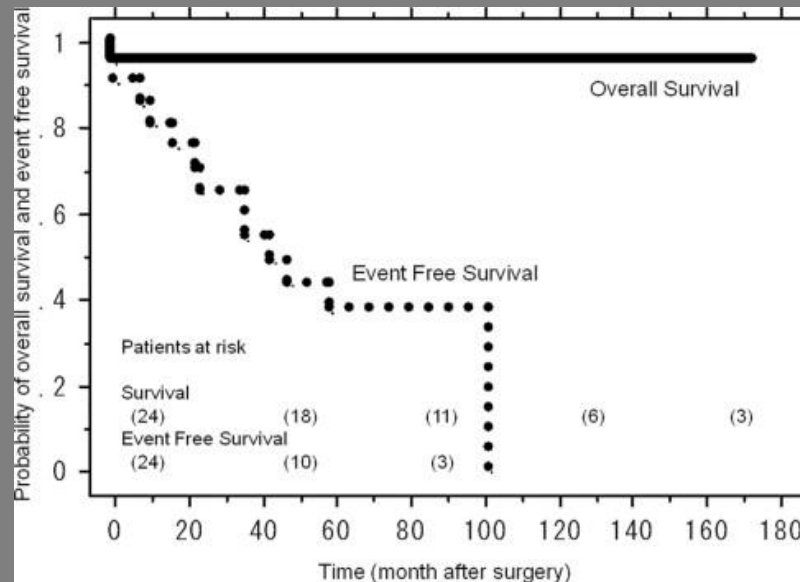


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Midterm Results of the Modified Ross/Konno Procedure in Neonates and Infants

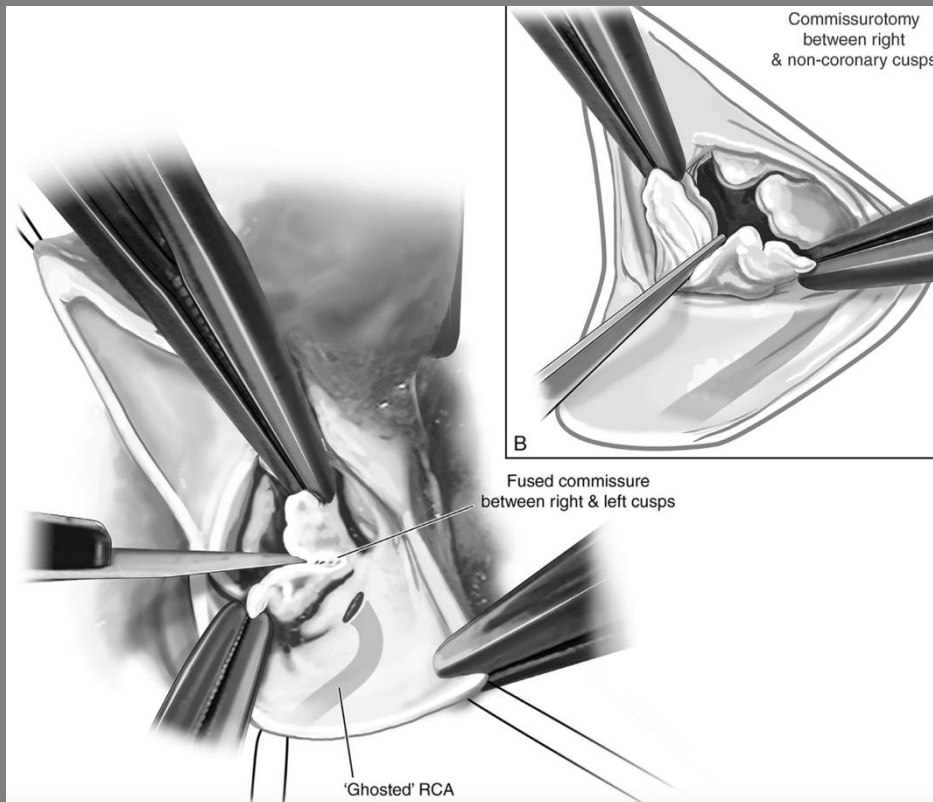
Presented at the Forty-seventh Annual Meeting of The Society of Thoracic Surgeons, San Diego, CA, Jan 31– Feb 2, 2011.

Katsuhide Maeda, MD, PhD^{*}, Rachel E. Rizal, BS, Michael Lavrsen, MD, Sunil P. Malhotra, MD, Sami A. Akram, MD, Ryan Davies, MD, Sam Suleman, BS, Olaf Reinhartz, MD, Daniel J. Murphy, MD, Frank L. Hanley, MD, V. Mohan Reddy, MD

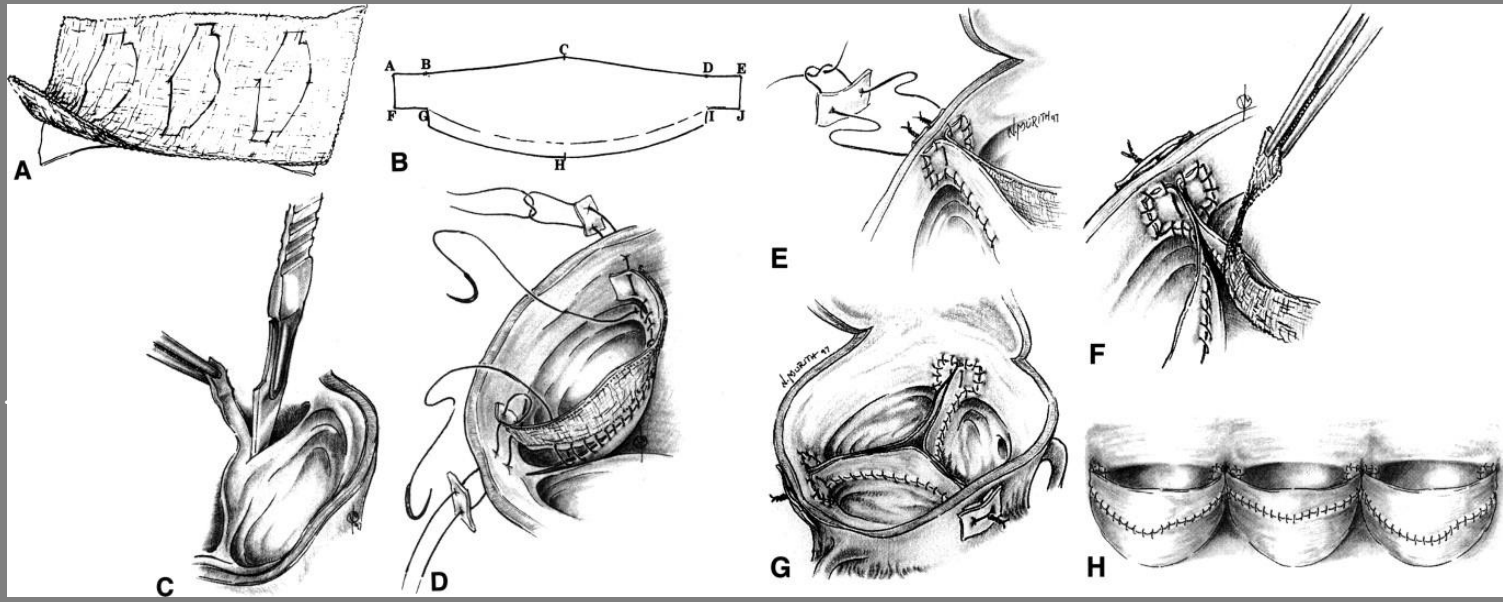
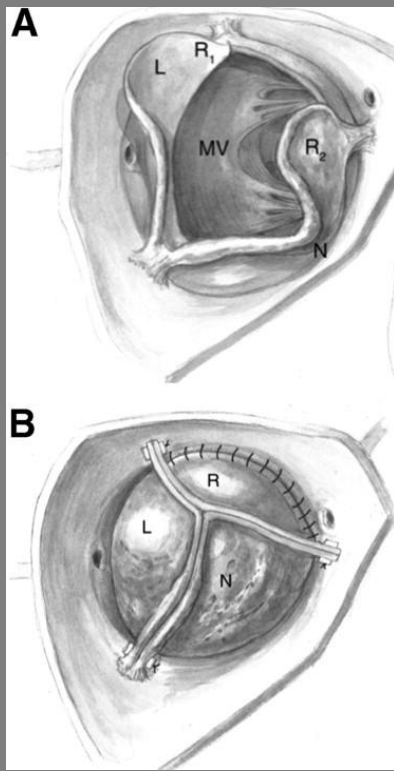


Aortic Valve Repair Techniques

Commissurotomy

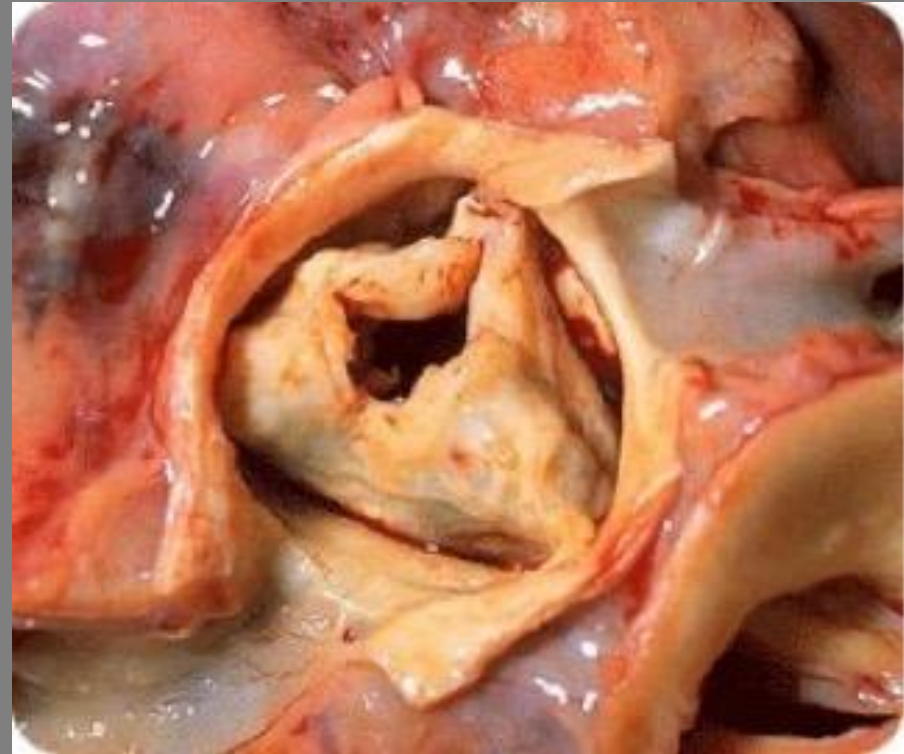
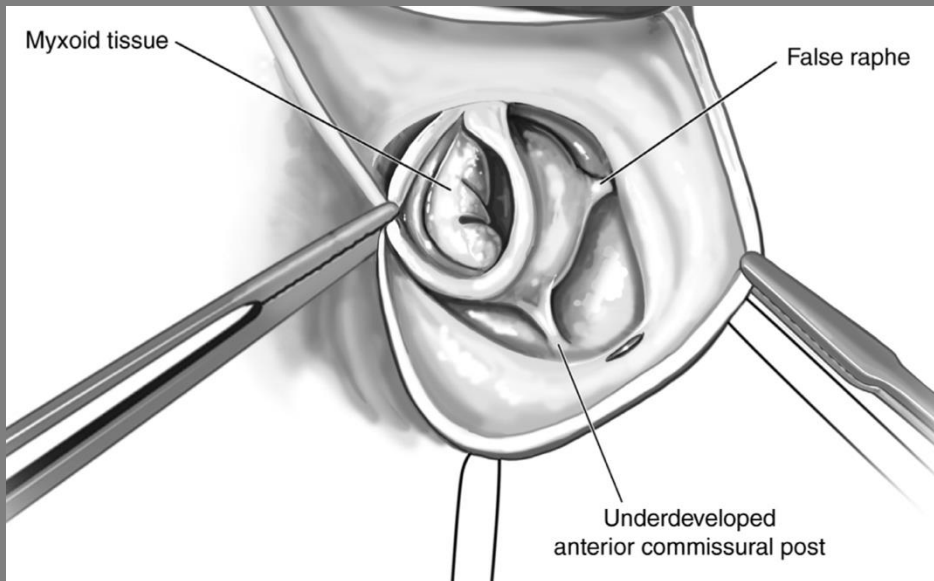


Aortic Valve Repair



Neonatal Critical Aortic Stenosis

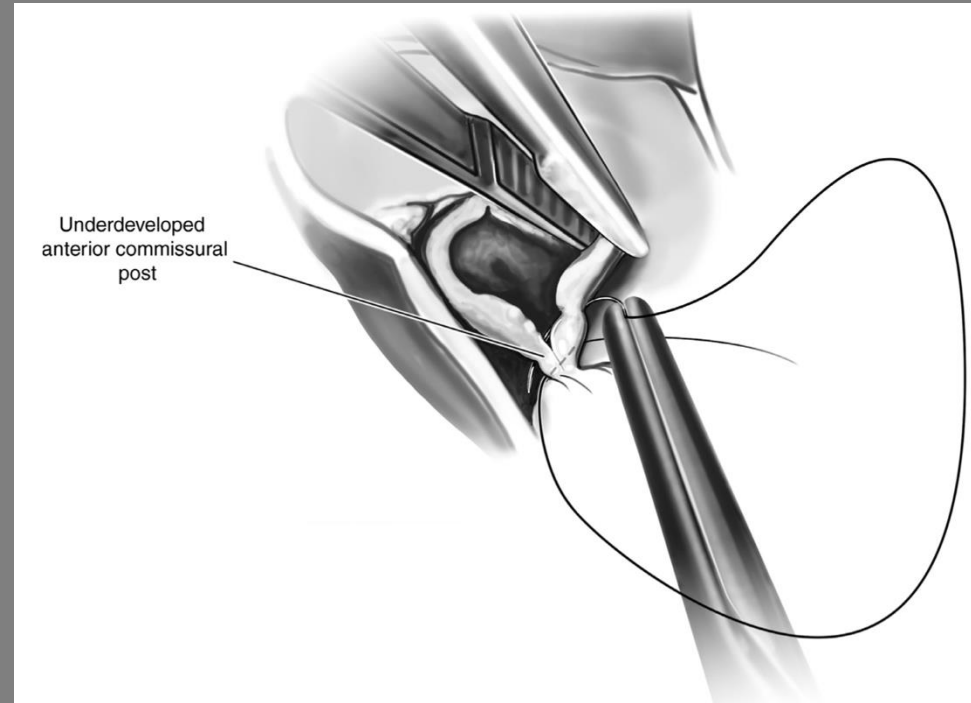
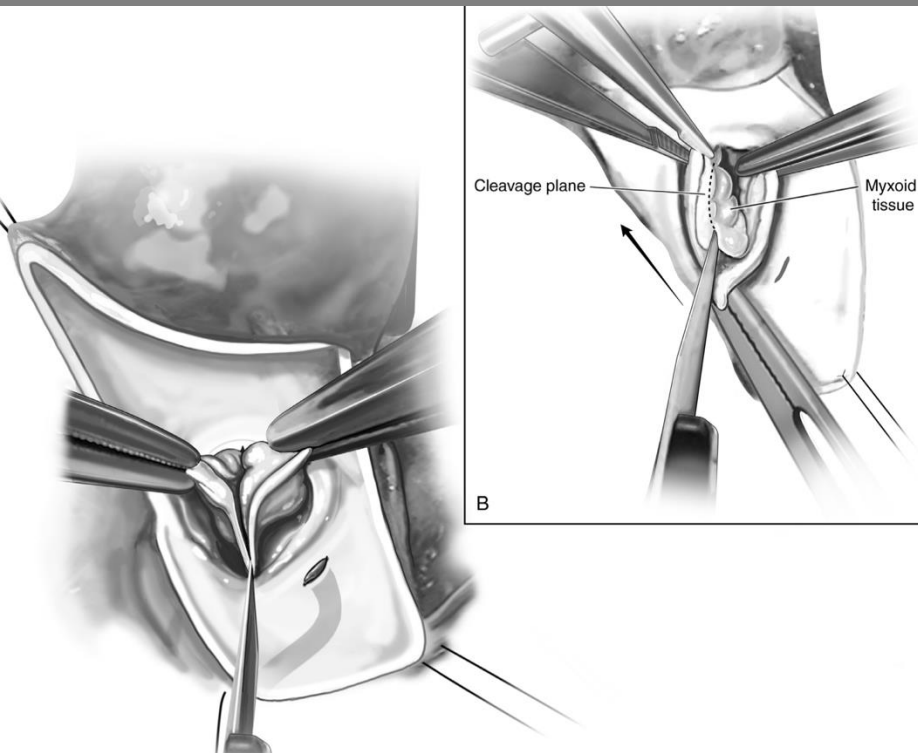
Unicuspid Aortic Valve



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Aortic Valve Repair Techniques Unicuspid Valve



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Personalized Care

- Patient characteristics
 - Non-cardiac
 - Prematurity
 - Weight
 - End-organ dysfunction
 - Renal worry about contrast
 - Neuro worry about bypass
 - Genetic syndromes

Personalized Care

- Patient characteristics
 - Cardiac
 - Hemodynamic stability
 - LV function
 - LV dilated vs hypertrophied
 - LV size – 2V vs single V
 - Other cardiac abnormalities
 - Hypoplastic Left Heart Complex
 - Consider Hybrid Stage 1
 - Beware creating AI secondary to balloon valvuloplasty

Personalized Care

- Left Ventricular Outflow Tract characteristics
 - Annulus size
 - ? Subaortic obstruction
 - Coronary artery pattern
 - Aortic valve leaflet structure and function

Recent Case

- 37week newborn with critical aortic stenosis
- Started on prostins and inotropic support
- Not intubated, no significant end-organ injury
- Improving LV function
- Adequate left sided structures
- Unicuspid aortic valve
- Multi-disciplinary Case Management discussion
 - Primary cardiology, cardiac intensivists, cardiac anesthesia, interventional cardiology, cardiac surgery
 - Consensus for surgical repair

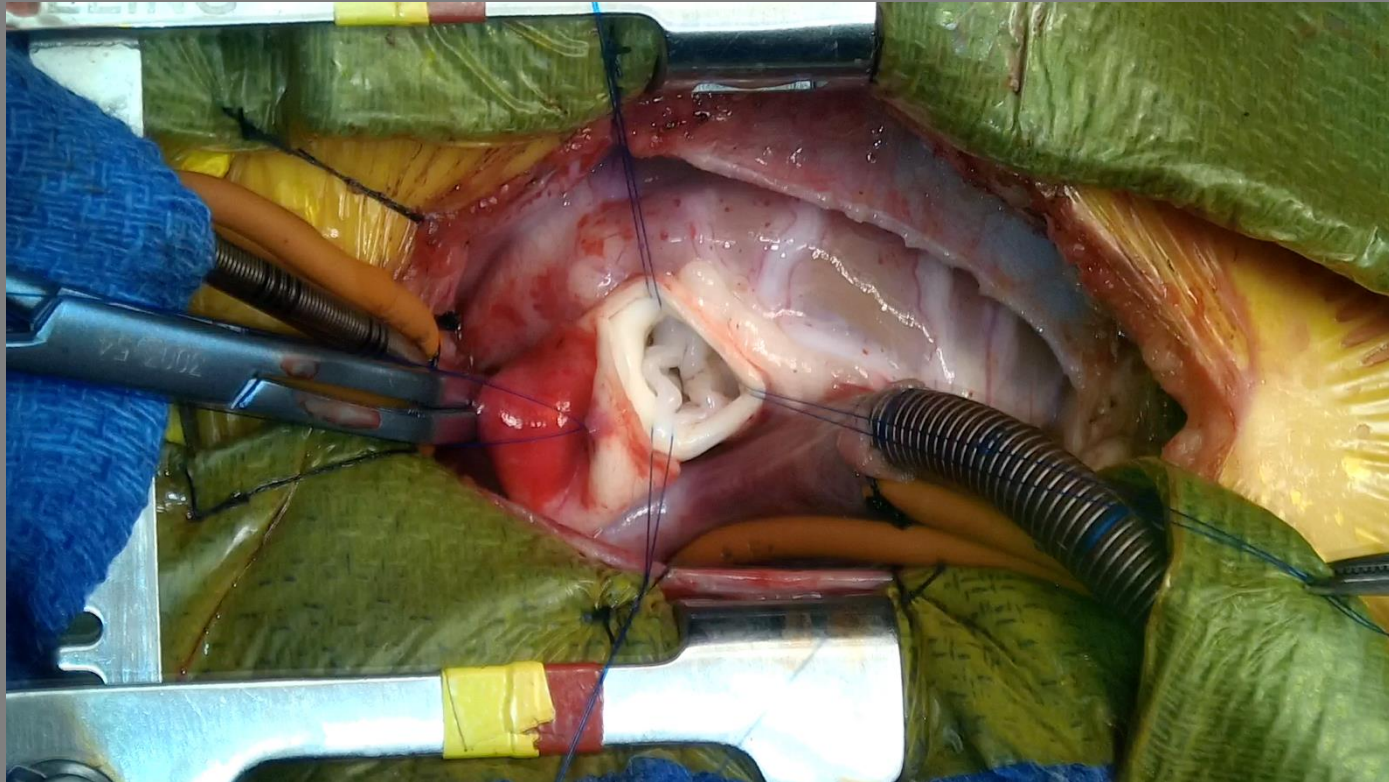


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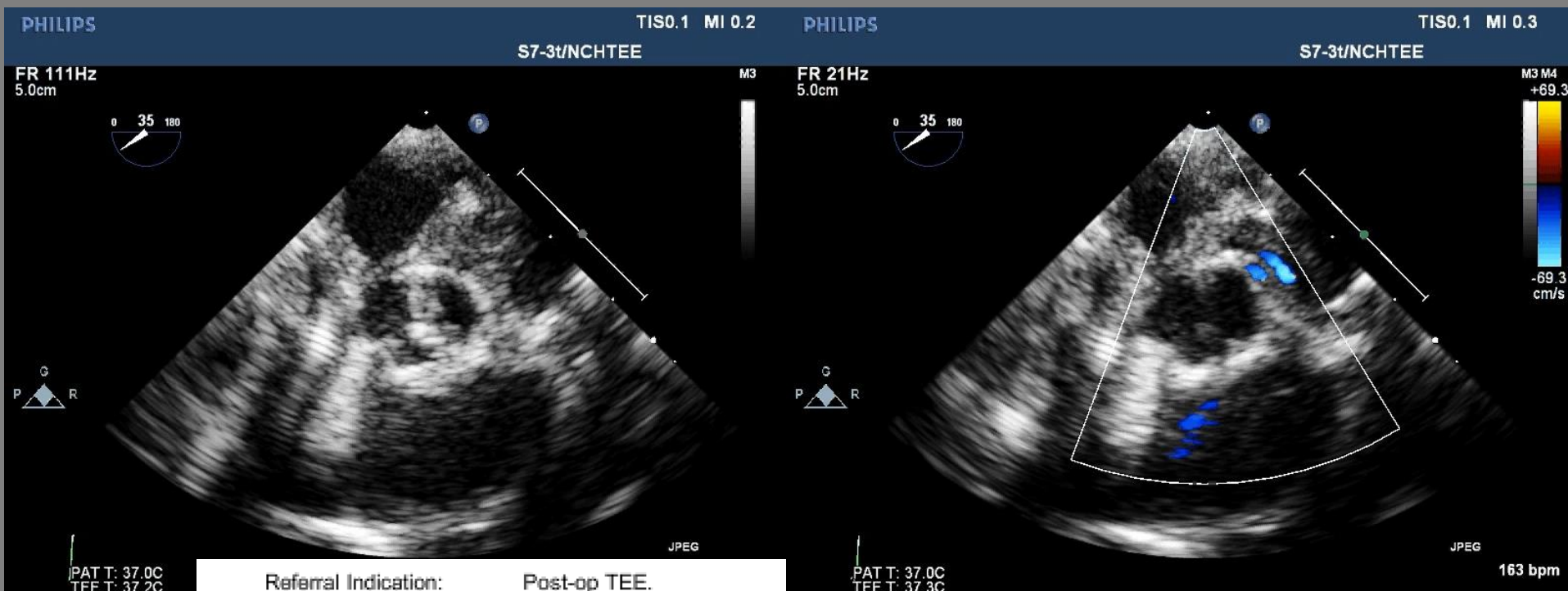
Unicuspid Aortic Valve Repair



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Post-op TEE

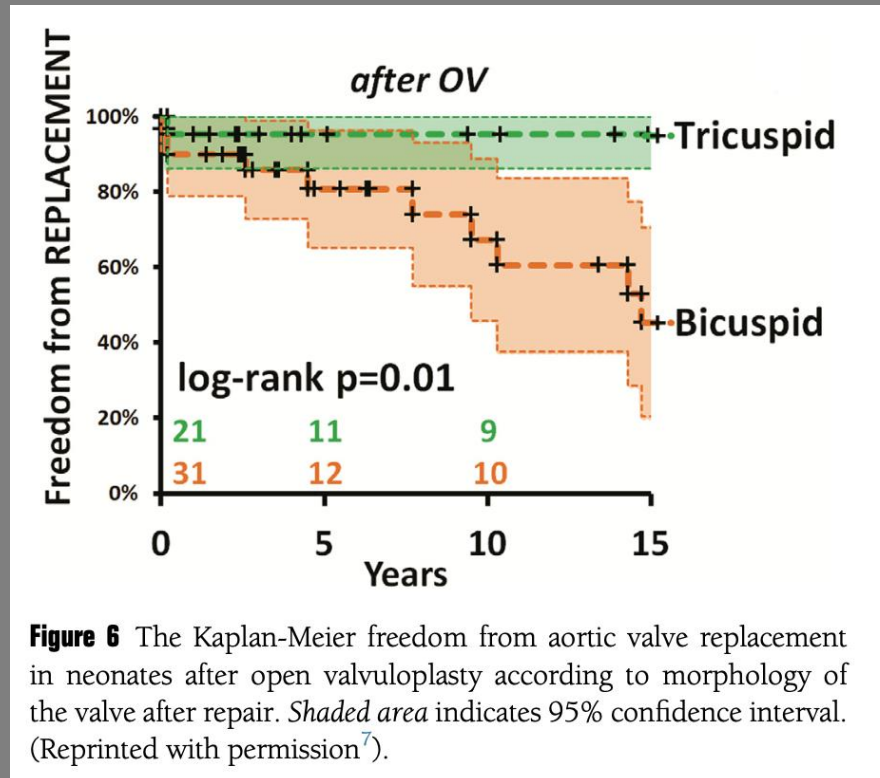


Referral Indication: Post-op TEE.
Procedures Performed: Transesophageal Echocardiogram: Congenital (including probe placement, 2D, Spectral Doppler and Color Flow)

SUMMARY:

1. Status-post aortic valve commissurotomy.
2. Aortic valve morphology has partial residual fusion of the right-non coronary cusps.
3. Mild aortic valve stenosis.
4. Trivial aortic valve regurgitation.
5. Trivial mid-cavitary left ventricular outflow tract obstruction.
6. Mild hypertrophy of the left ventricle.
7. Hyperdynamic left ventricular systolic function.
8. Normal right ventricular size and systolic function.
9. A transesophageal echocardiogram was performed in the operating room under general anesthesia.. The pediatric transesophageal echo probe was placed and removed without difficulty.

Results Aortic Valve Repair



Vergnat M, Asfour B, Arenz C, et al: Aortic stenosis of the neonate: A single-center experience. J Thorac Cardiovasc Surg. 157:318–326, 2019. e1

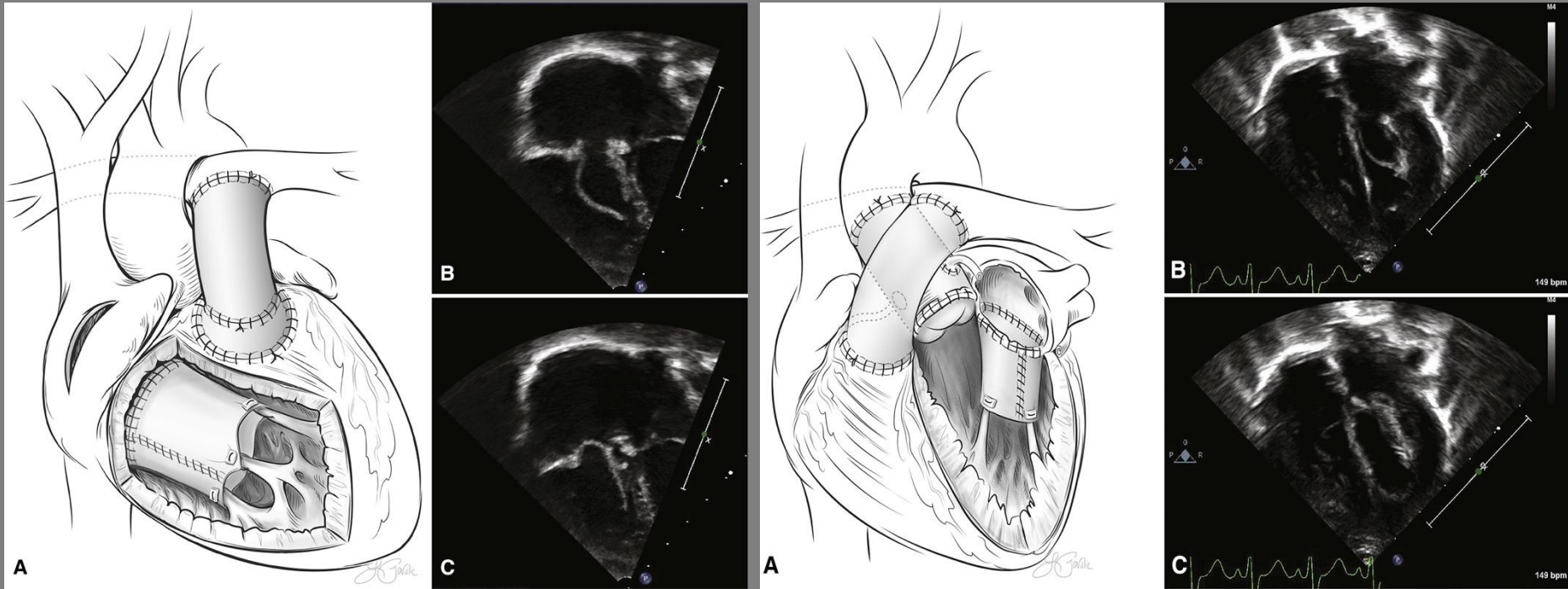


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Evolving Techniques



The Journal of Thoracic and Cardiovascular Surgery 2017 154:e57-e59DOI: (10.1016/j.jtcvs.2017.03.129)

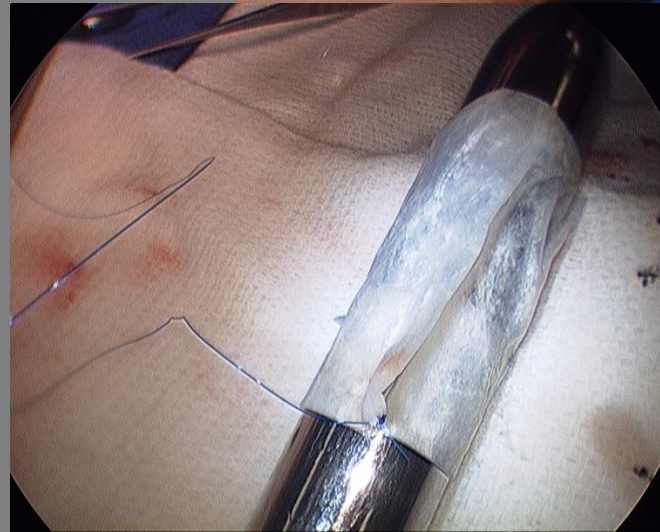
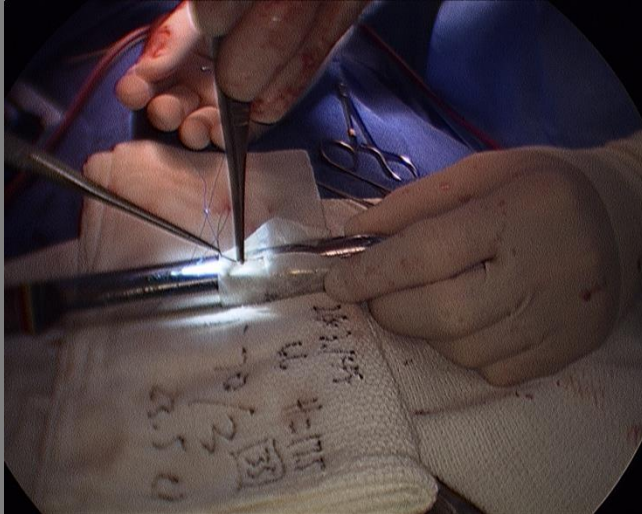
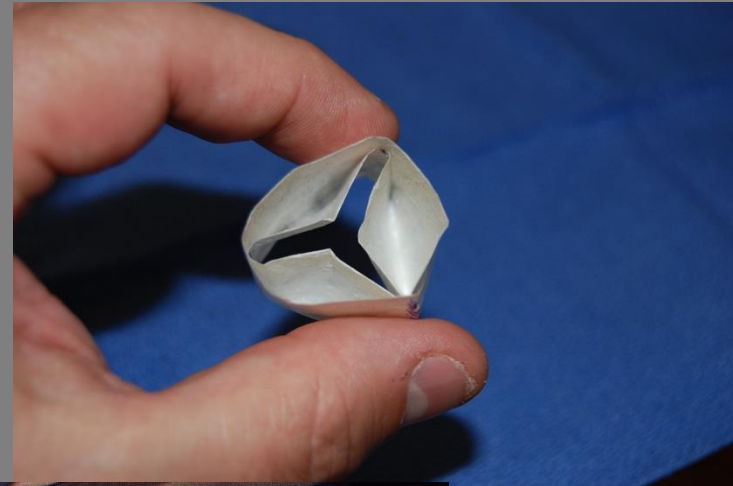
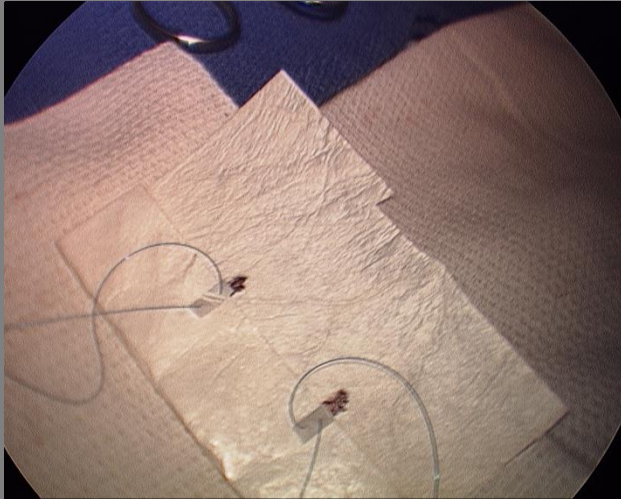


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Creating an Aortic Root Valved Conduit from ECM



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“Japanese” ePTFE pulmonary valve

- Synthetic leaflets; durable
 - No calcification, no incidence of endocarditis
- Not growable, but durable
- Rare usage in the aortic position
 - Including current patient at NCH

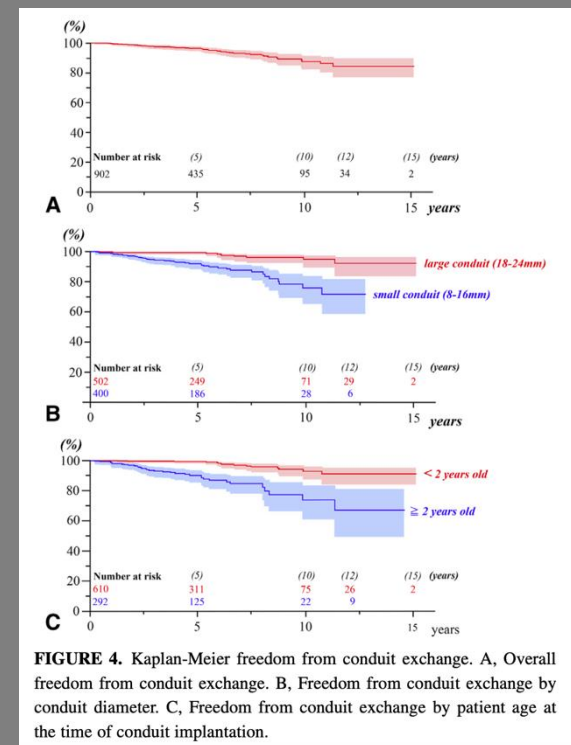
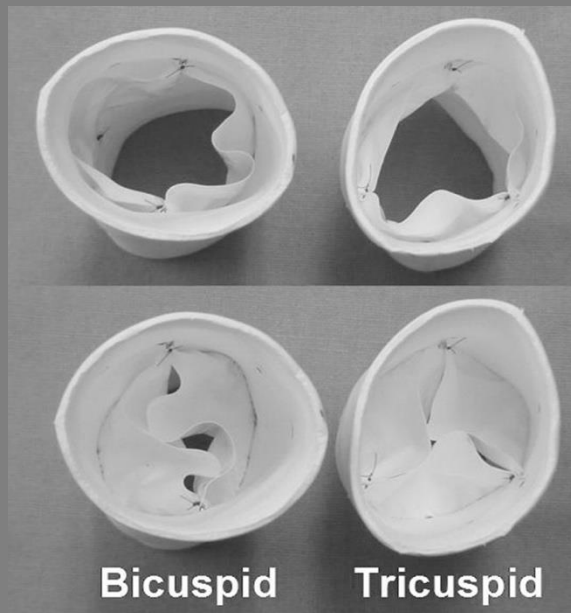


FIGURE 4. Kaplan-Meier freedom from conduit exchange. A, Overall freedom from conduit exchange. B, Freedom from conduit exchange by conduit diameter. C, Freedom from conduit exchange by patient age at the time of conduit implantation.



Emerging Surgical Options

CONGENITAL: PULMONARY VALVE

Novel size-adjustable pulmonary valve US early feasibility study: One-year outcomes

 Check for updates

Mark E. Galantowicz, MD, Corey A. Stiver, MD, Oliver M. Barry, MD, Emile A. Bacha, MD, Kanwal M. Farooqi, MD, Gerald R. Marx, MD, Diego Porras, MD, Christopher W. Baird, MD and Aimee K. Armstrong, MD

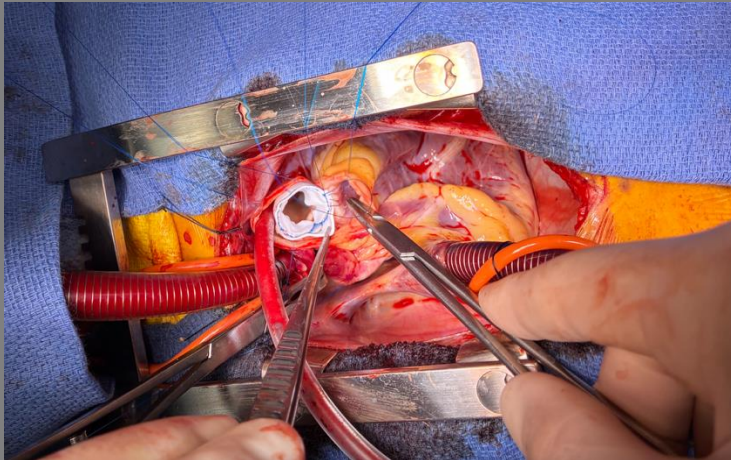
ABSTRACT

Objective: The Autus Size-Adjustable Valve (ASAV) is a novel surgically implanted fully synthetic expandable pulmonary valve designed for pediatric patients. This first-in-human study evaluated initial device feasibility and safety.

Methods: This was a Food and Drug Administration–approved prospective, single-arm, multicenter Investigational Device Exemption Early Feasibility Study to evaluate safety and preliminary effectiveness of the ASAV in pediatric patients aged 18 months to 16 years who require pulmonary valve replacement. All potential subjects underwent review by a screening committee to determine eligibility. Subjects had pre- and postoperative evaluation via transthoracic echocardiography. One-year outcomes are reported.



Novel surgically implanted size-adjustable synthetic pulmonary valve.



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Evolving Techniques

Right Atrial Appendage for Aortic Valve Reconstruction

Paighton C. Miller, MD,¹ Jacob R. Miller, MD,² Chelsea T. Mannie, BSN, CPN,² Dilip S. Nath, MD,² and Pirooz Eghtesady, MD, PhD²

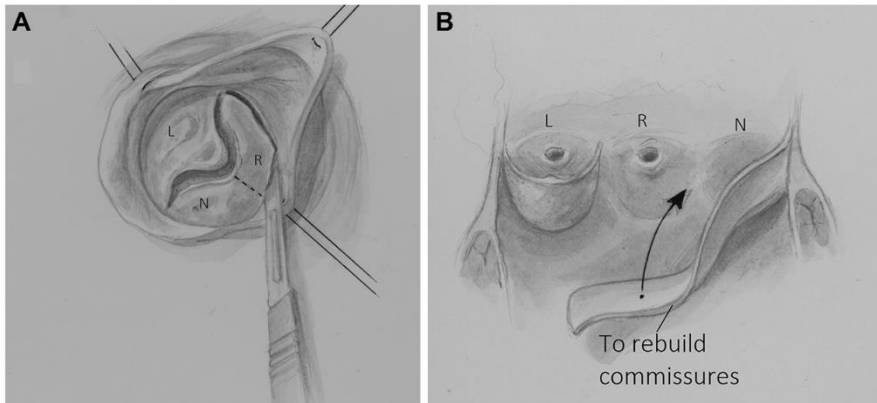


FIGURE 3 The right coronary leaflet (R) is (a) cut from the wall and (b) mobilized to elevate the height of the right-noncommissure to the correct position. (L, left coronary leaflet; N, noncoronary leaflet.)

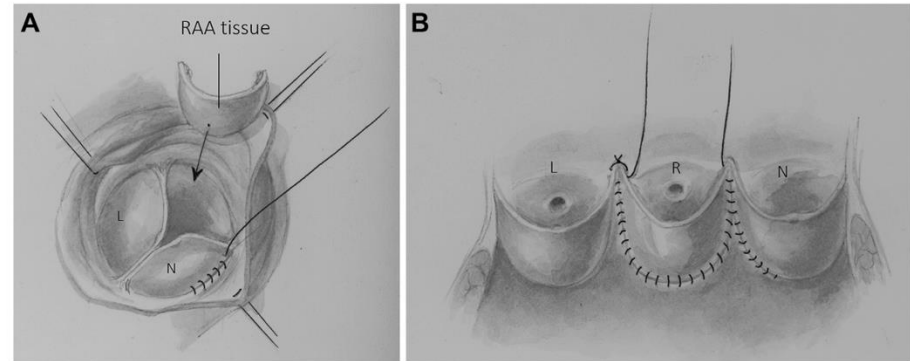


FIGURE 4 (a) The neoleaflet is lowered into the aortic annulus with the smooth surface facing the left ventricular outflow tract. (b) The neoleaflet is sewn in from the nadir to the commissures in a running fashion. (L, left coronary leaflet; N, noncoronary leaflet; R, right coronary leaflet; RAA, right atrial appendage.)

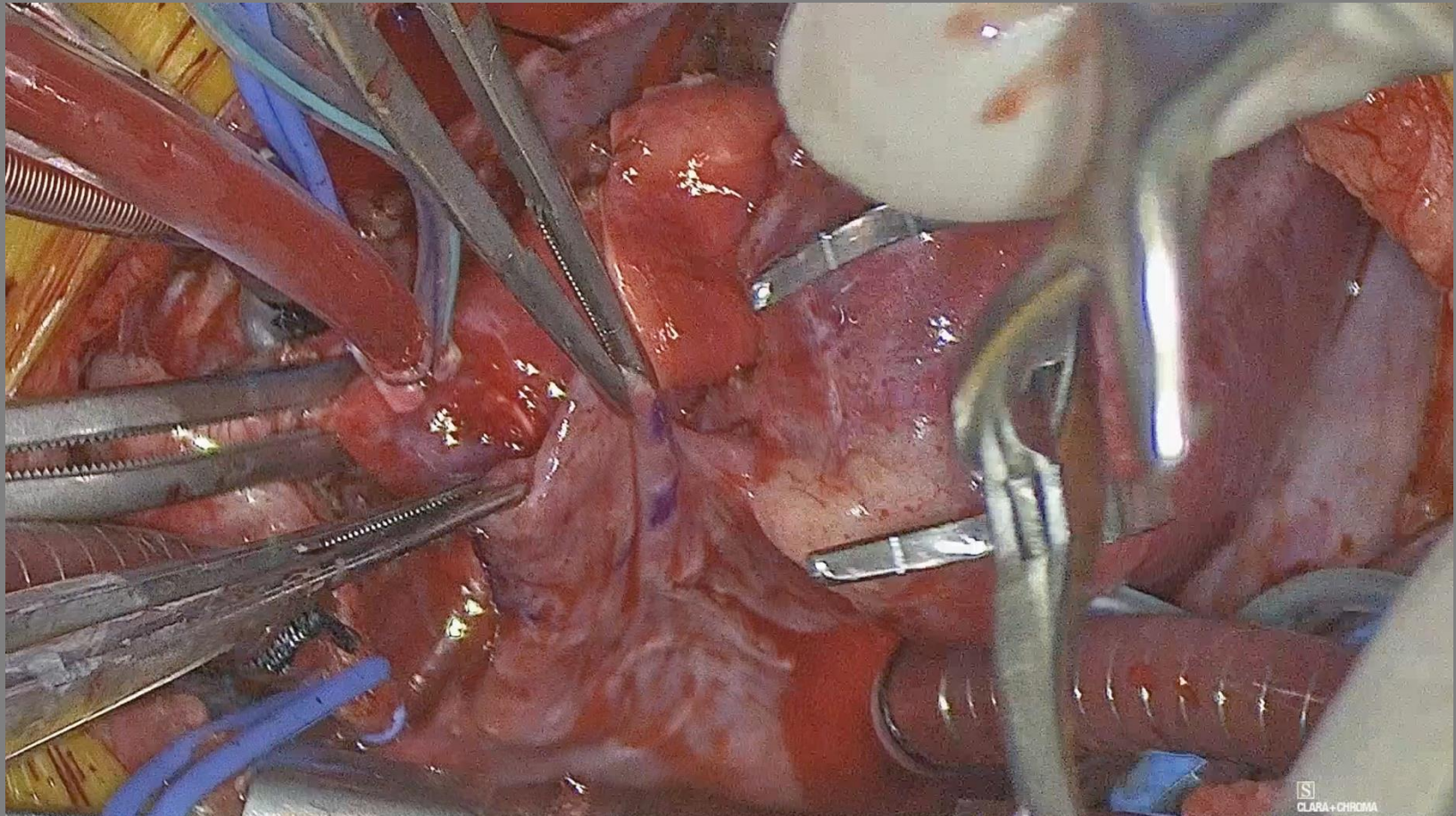


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Atrial Appendage Valve



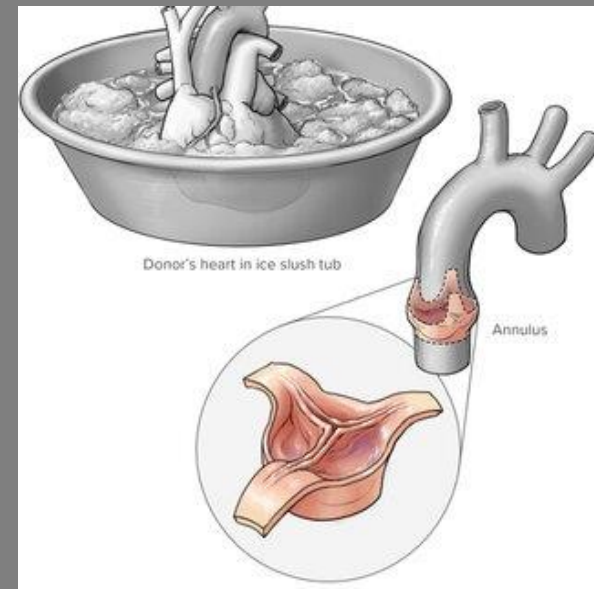
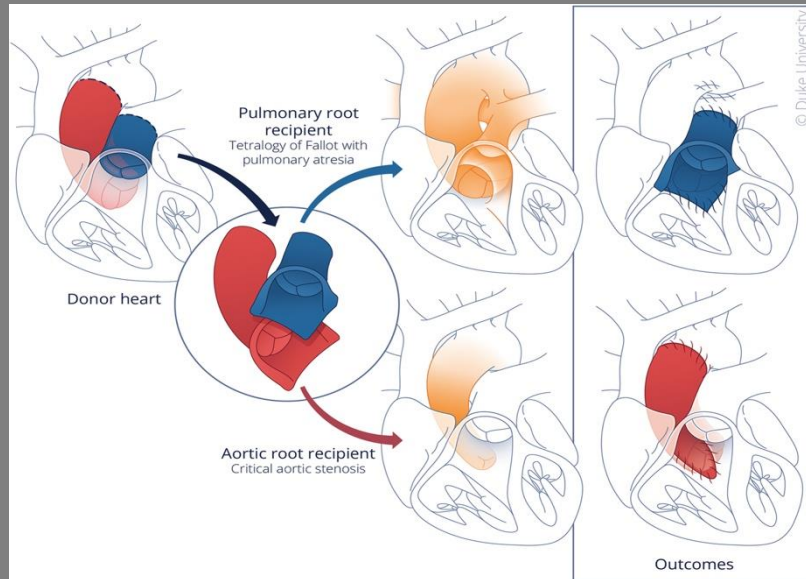
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 **THE HEART CENTER**

Partial Heart Transplant for Congenital Heart Disease

Douglas M Overbey^{1 2 3}, Berk Aykut^{1 3}, John A Kucera¹, Cathlyn K Medina¹, Neeta J Sethi², Piers C A Barker², Erin V Shea², Joseph W Turek^{1 2 3}

- Living semi-lunar valve allotransplantation
 - Grows to match somatic growth just like a full heart transplantation in children
 - Requires low dose immunosuppression



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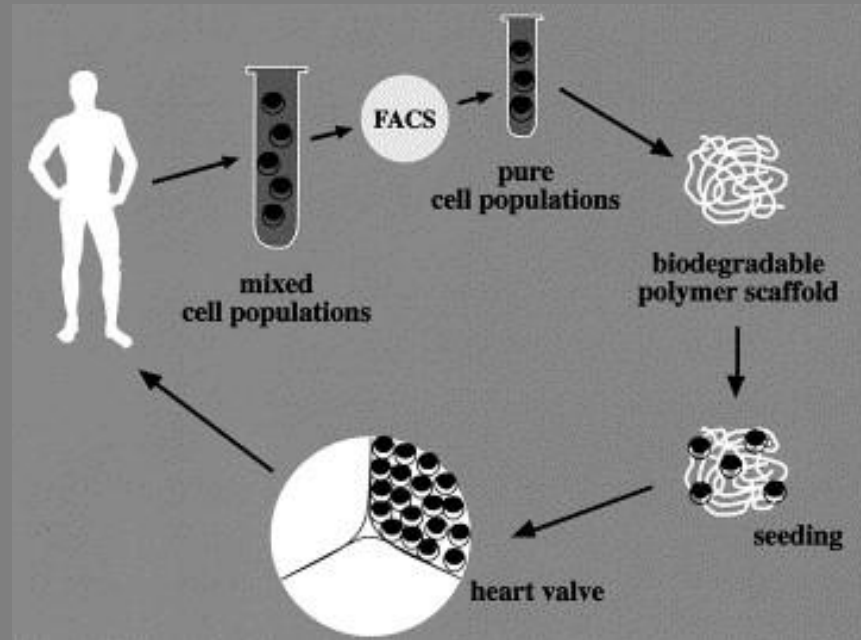
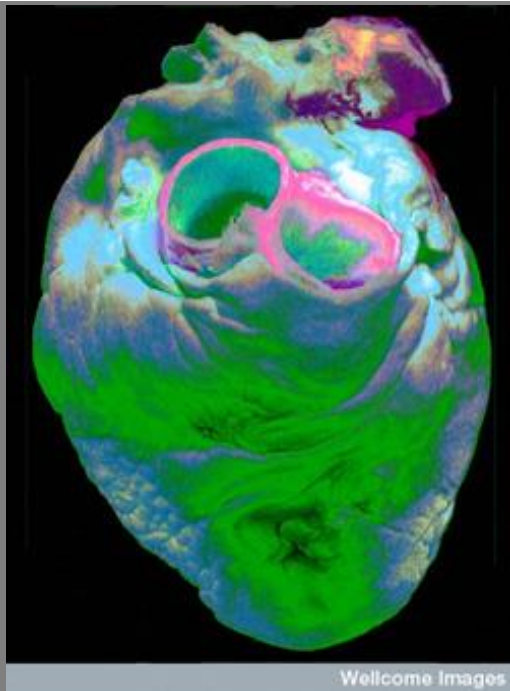


THE HEART CENTER

Tissue Engineered Heart Valves: Autologous Cell Seeding on Biodegradable Polymer Scaffold

Toshiharu Shinoka

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Conclusions

- It's not whether a surgical vs transcatheter approach to neonatal aortic valve stenosis is better – rather, it is understanding which patient and valve characteristics favor either approach
- Aortic valve repair and/or Ross procedure are currently the best surgical options, until there is a growable aortic valve replacement option – the hope of tissue engineered vascular grafts!