

Aorta Live 2017
Hamburg, Germany

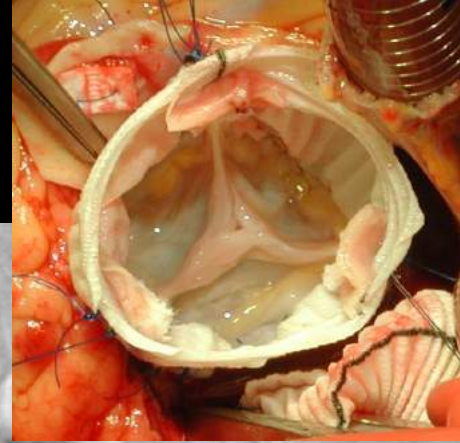
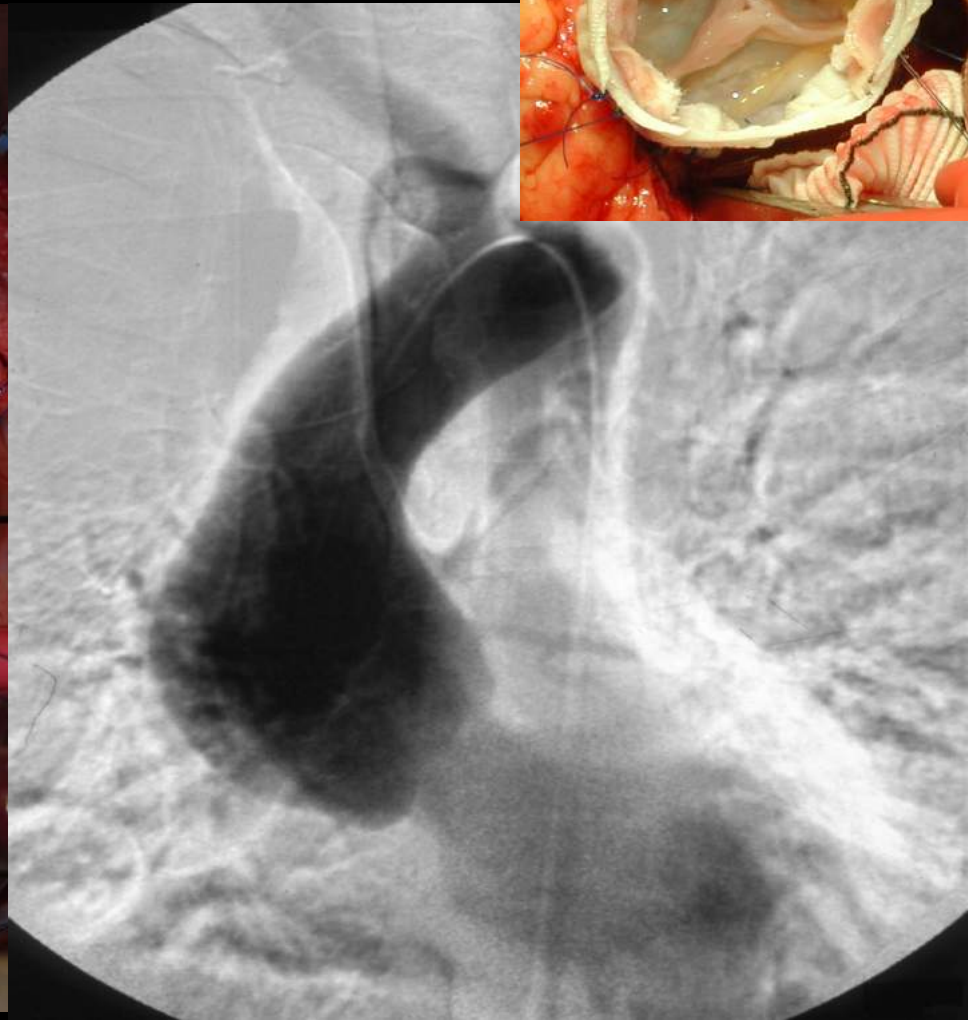
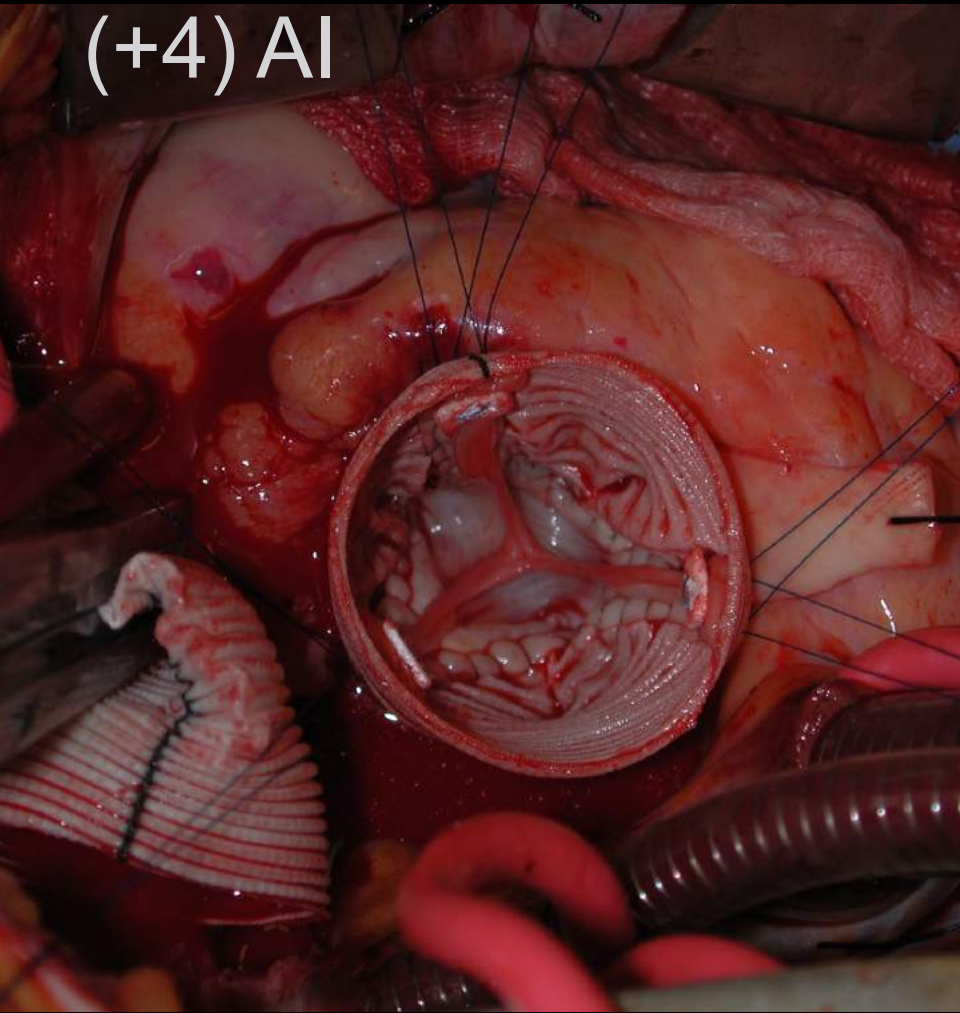


BAV Repair with Reimplantation: State of the Art

Aorta Live: Hamburg 2017

Joseph E. Bavaria, M.D.
Roberts-Measey Professor and Vice Chief
CardioVascular Surgery
Director: Thoracic Aortic Surgery Program
University of Pennsylvania, USA
Immediate Past-President of STS

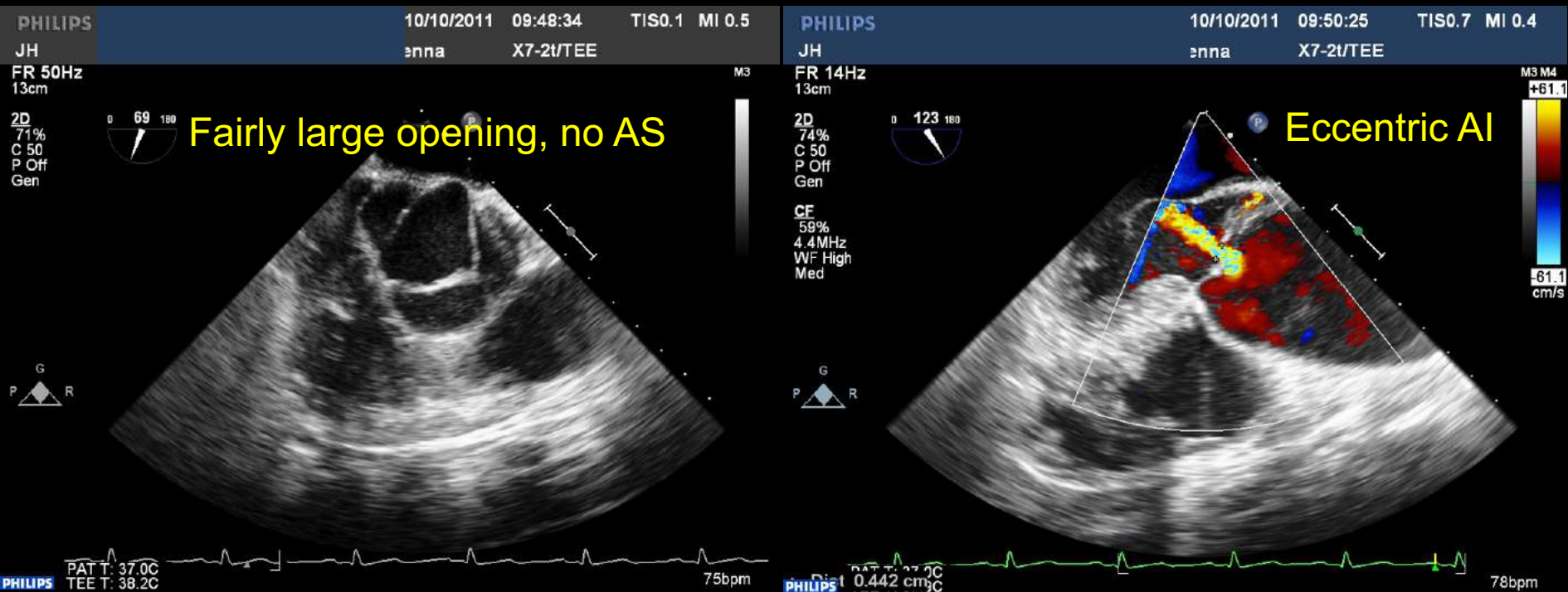
Marfan's Sinus of ValSalva Aneurysm (7.0 cm.) with Severe (+4) AI



Valve Sparing ?? Too much AI, too much aneurysmal dilation, too much leaflet surface area,

The Pure AI BAV Patient with Dilated/Aneurysmal Proximal aorta

NOTE; Pure AI, No Calcified Leaflets



Still frames to depict anatomy



2002 to 2017: 1198 patients with Bicuspid Aortic Valve Disease (the surgical practice BAV universe)

*AS ± AI or AI for isolated AVR (N=804)
EXCLUDED
AVR, Bentall, Wheat

Valve Pathology (N= 1198)

AI ± aortic root aneurysm (N=394)

Total BAV Repair = 146

Primary Leaflet Repair ± Ascending Aorta Replacement (N=84)

Since 2005

Primary Leaflet Repair + Root Reimplantation (N=62)

Since 2006

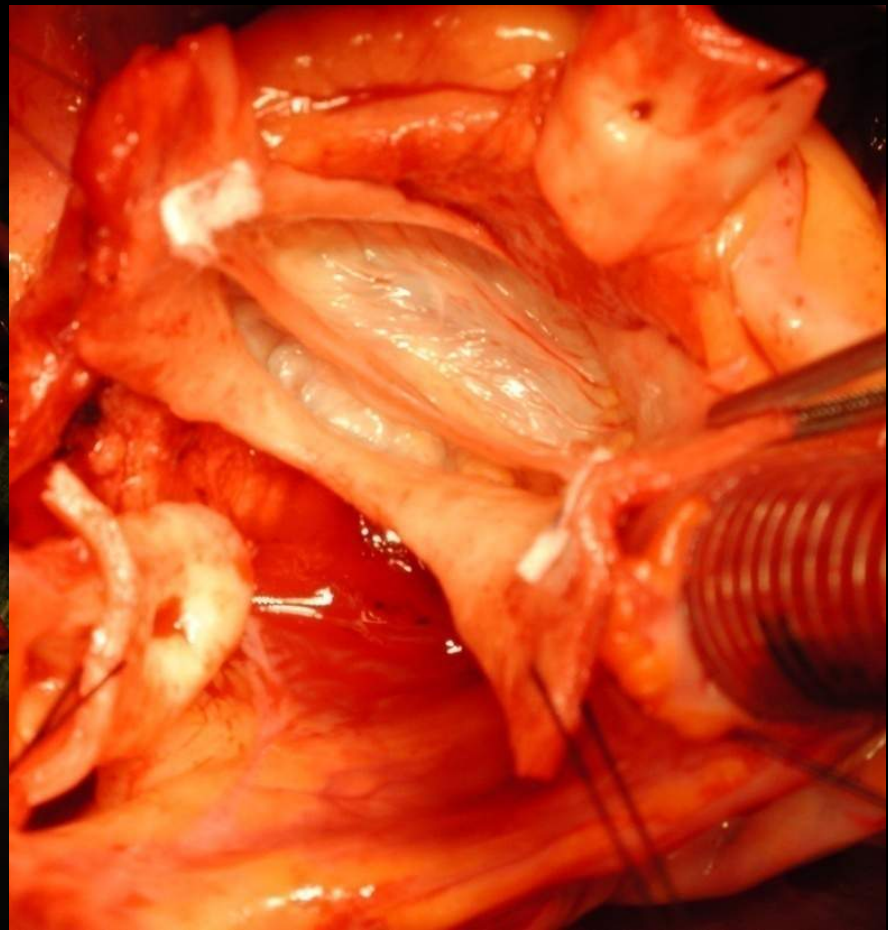
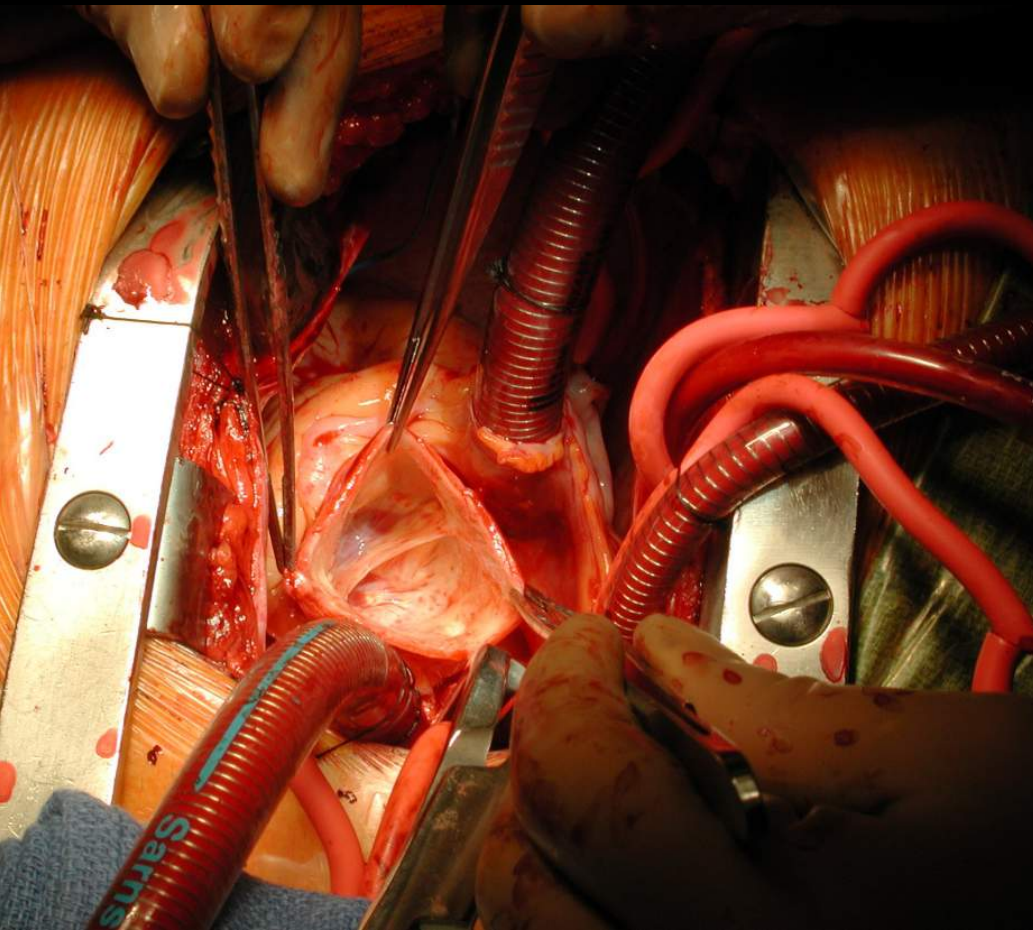
Bentall or Proximal Aortic Reconstruction (N=248)

2006-2016

Bavaria, JE 4/2017



David V/ Bicuspid Valve: Sievers o 180/180 Beautiful Valve!!



Because we can't throw Valves like this in the BUCKET!!

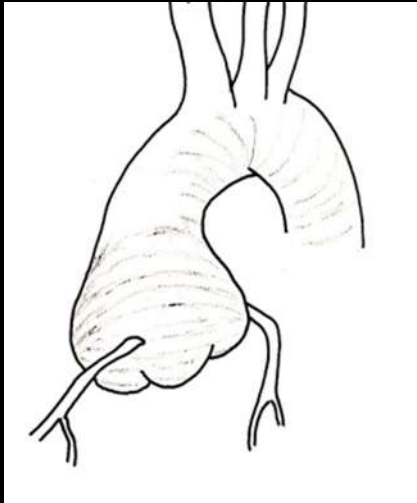


Ascending Aorta - Root (Sinus segment) Phenotype



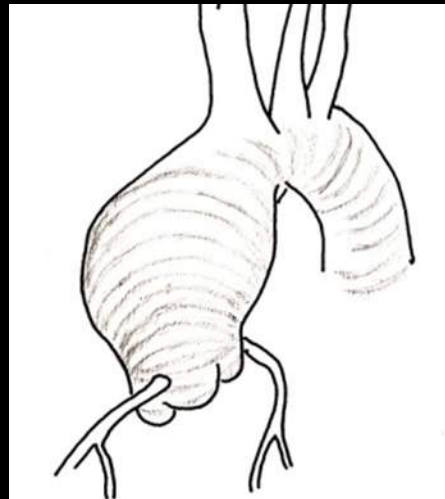
Root aneurysm

Valsalva ≥ 45 mm



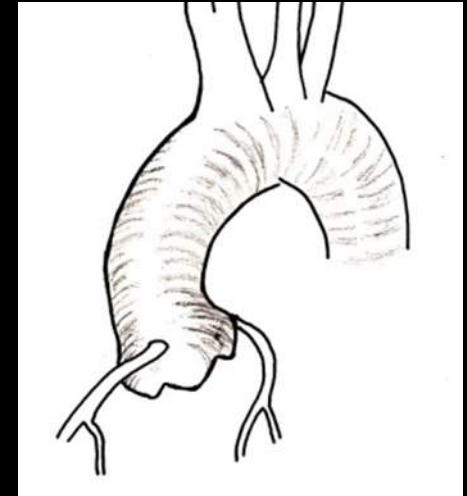
Supra coronary aneurysm

Valsalva $\leq 40-45$ mm



Isolated AI

All diameters ≤ 40 mm



Adapted From E. Lansac, Paris France

What about AI?



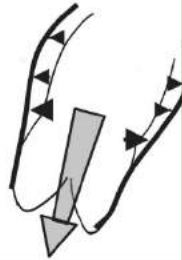
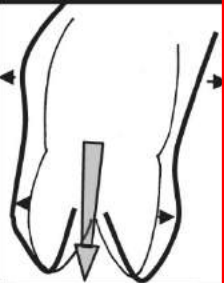
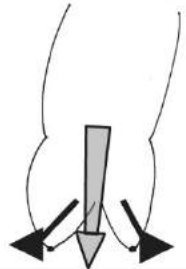
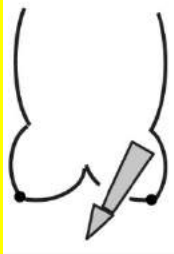

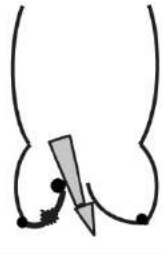
BAV Repair Philosophy: The Basics for AI

In Evolution!

Surgical Repair BAV AI Classification:

Fundamentally we are discussing Ib and c with II

Most Common combination

AI Class	Type I Normal cusp motion with FAA dilatation or cusp perforation				Type II Cusp Prolapse	Type III Cusp Restriction
	Ia	Ib	Ic	Id		
Mechanism						
Repair Techniques (Primary)	STJ remodeling <i>Ascending aortic graft</i>	Aortic Valve sparing: <i>Reimplantation or Remodeling with SCA</i>	Ring	Patch Repair <i>Autologous or bovine pericardium</i>	Prolapse Repair <i>Plication Triangular resection Free margin Resuspension Patch</i>	Leaflet Repair <i>Shaving Decalcification Patch</i>
(Secondary)	SCA		STJ Annuloplasty	SCA	Ring	SCA

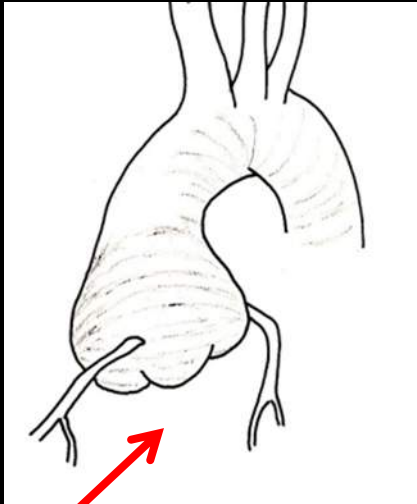
BAV Ib + II usually associated with 15-25% larger annulus than standard for BSA

Ascending Aorta - Root (Sinus segment) Phenotype



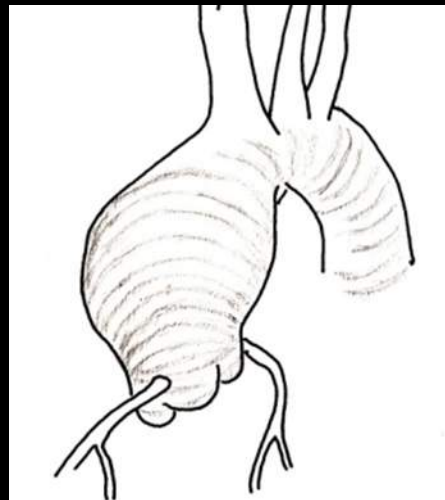
Root aneurysm

Valsalva ≥ 45 mm



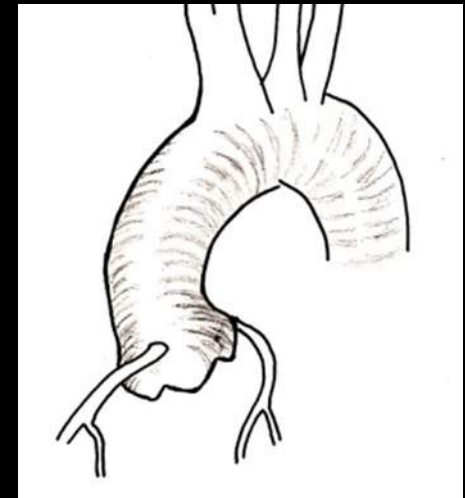
Supra coronary aneurysm

Valsalva $\leq 40-45$ mm



Isolated AI

All diameters ≤ 40 mm

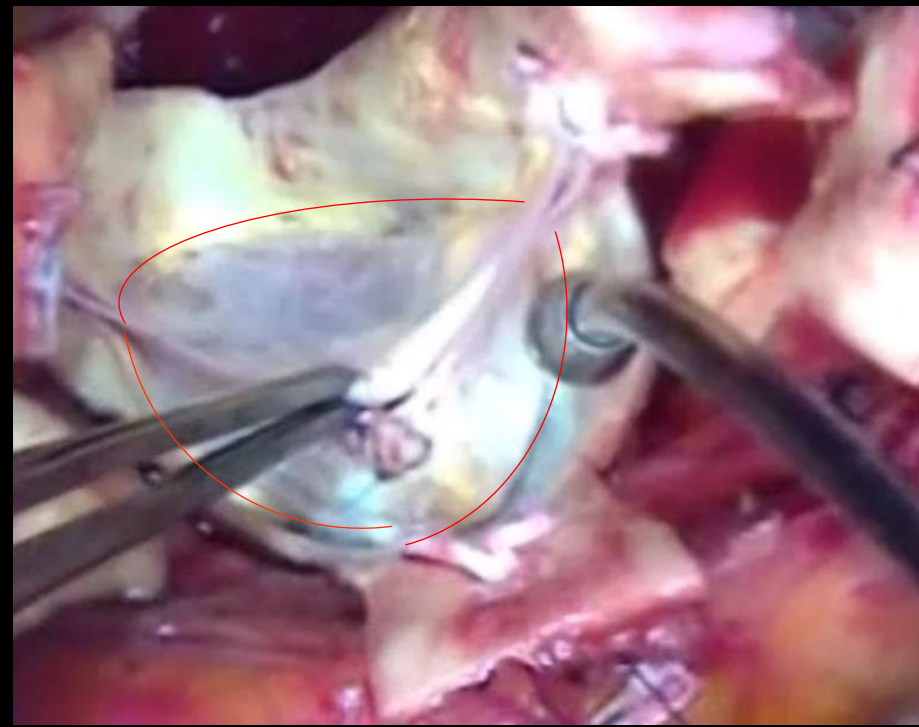
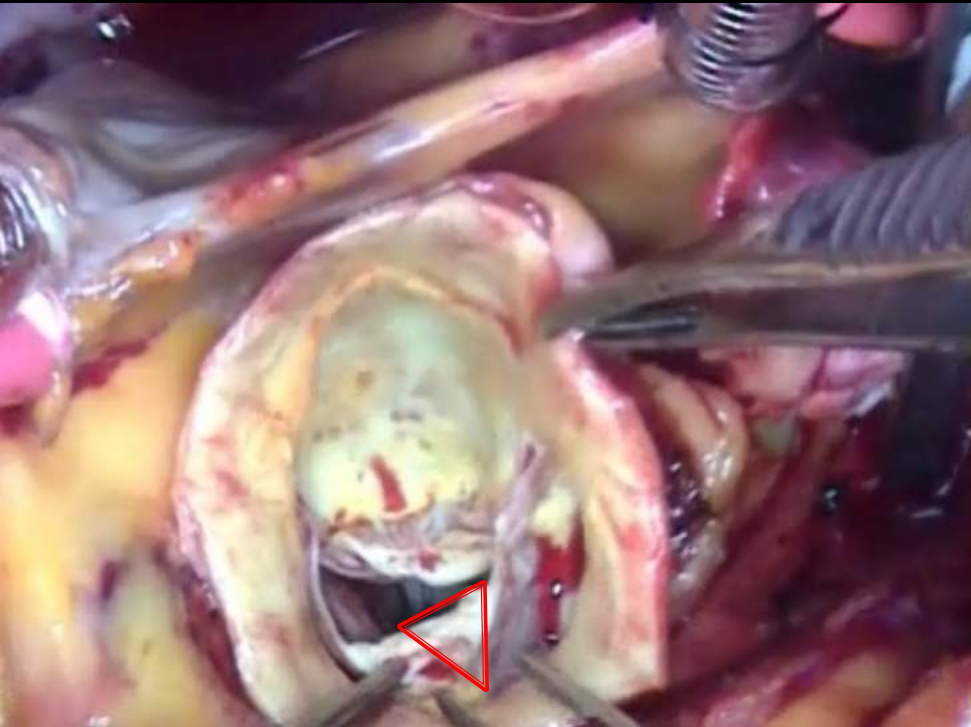


Adapted From E. Lansac, Paris France

Measuring the Amount of excess leaflet to resect (or plicate) for Leaflet Free Margin Equality Treating the Prolapse

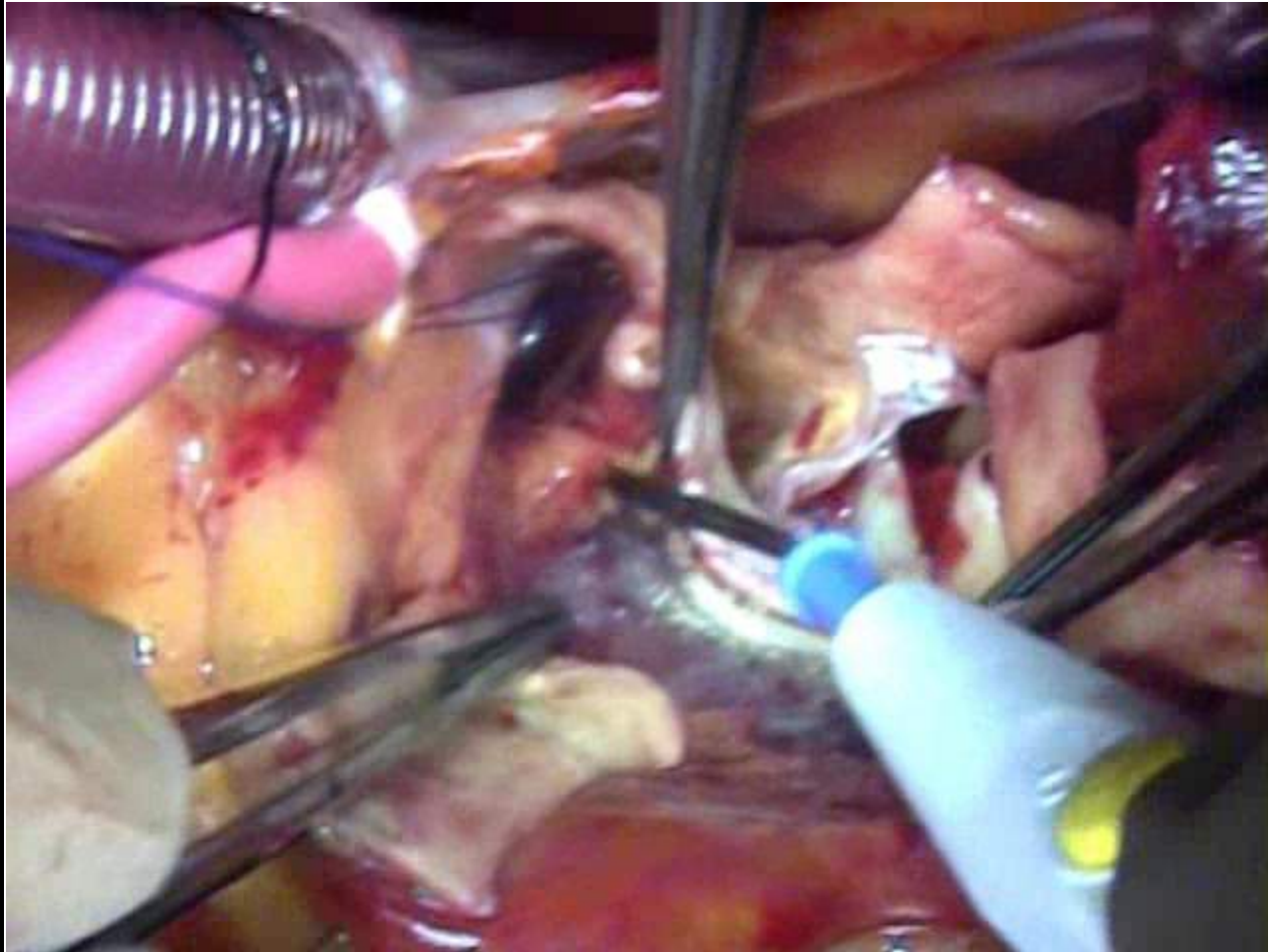


Raphe Release, Equalization of Free Margin, and Plication/Resection of Redundant leaflet

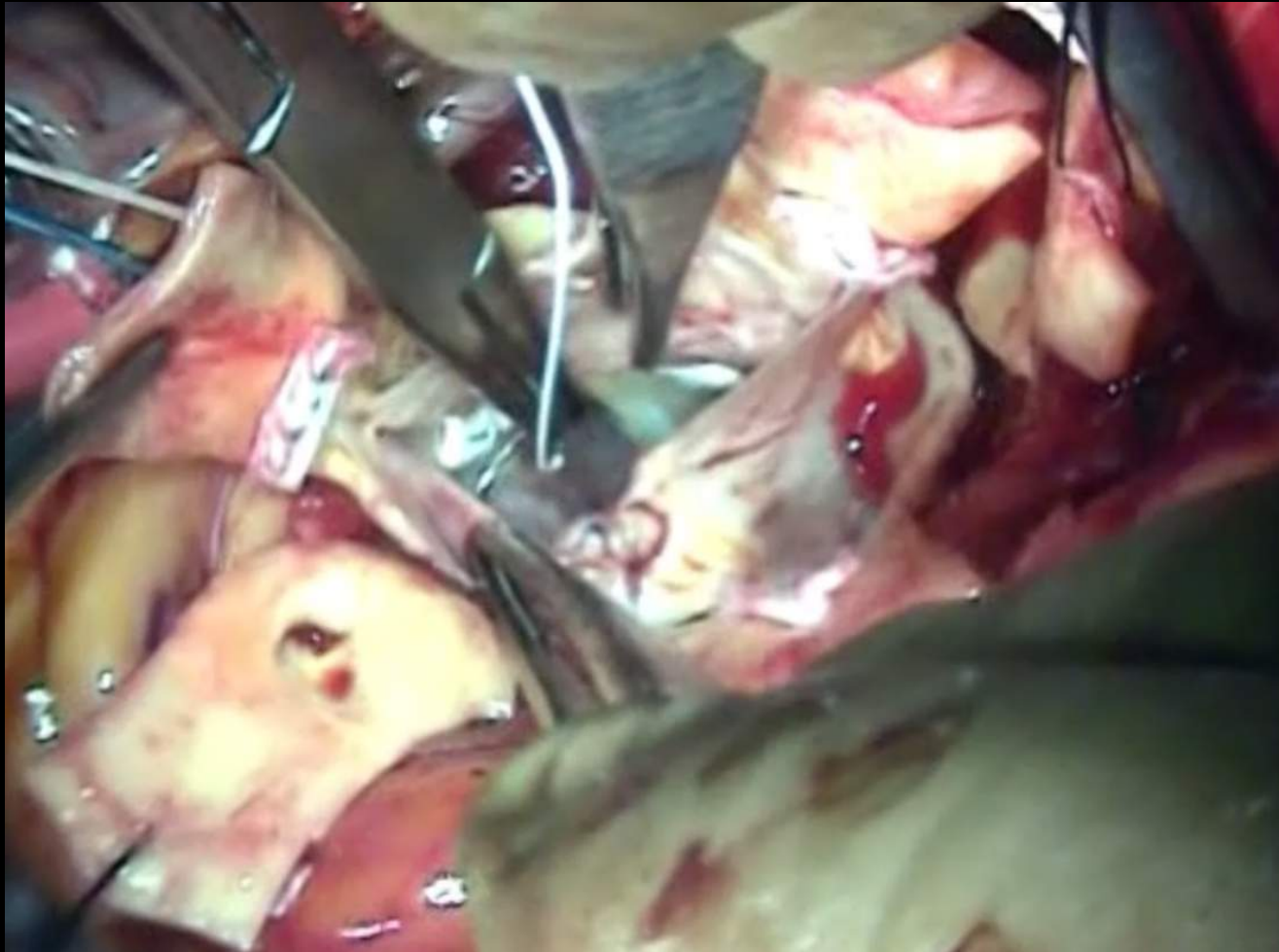


Coronary Buttons are cut.
210/150 perimeter and Leaflet
surface area ratios. (vs 180)

Preparation of the Root for Subannular Suture Placement and Re-Implanation Procedure



Placement of Sub-Annular “Fixation” Sutures for Annular Reduction and Stabilization

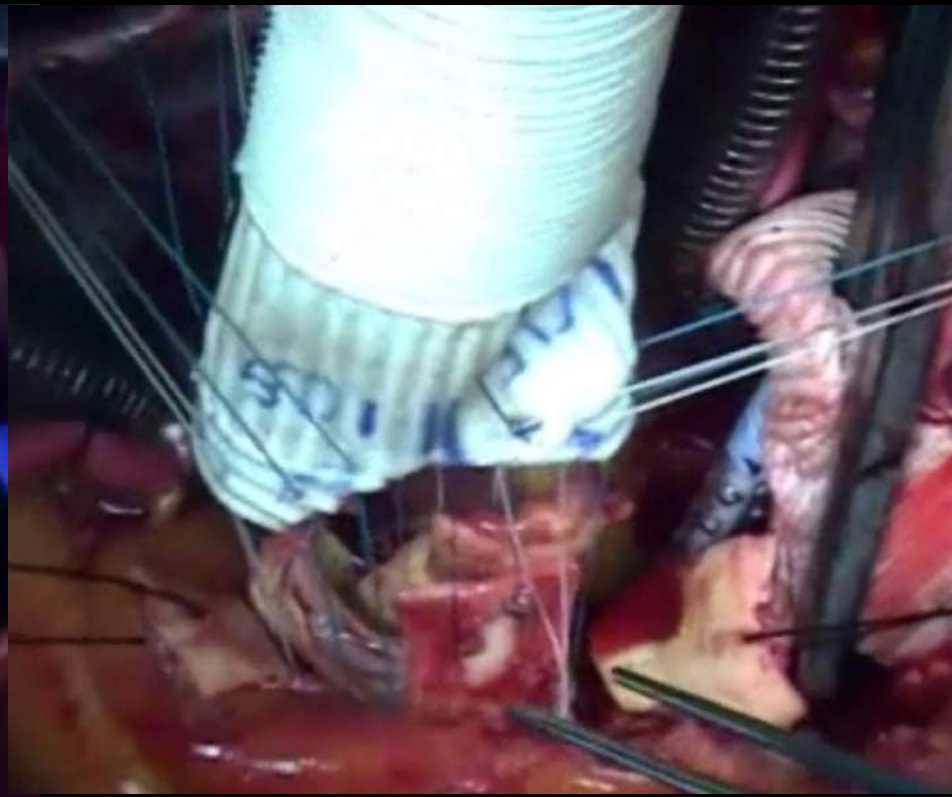


8-9 Geometrically placed Subannular Stabilization sutures (annular reduction 15-20%)

Construction of Stable (smaller) Annulus and Re-implantation of the “New Root” in 3 dimensions



In BAV: Size the annulus for “the normal annular diameter” for each individual



210°/150° Neo ValSalva Root (Raphed BAV); 50% are 180/180



***BAV Cusp Repair with
Reimplantation (VSRR):
What's (and Where is) the
DATA??***



Brussels Group: Gebrine El-Khoury: JTCVS 2011

Acquired Cardiovascular Disease

de Kerchove et al

Valve sparing-root replacement with the reimplantation technique to increase the durability of bicuspid aortic valve repair

Laurent de Kerchove, MD,^a Munir Boodhwani, MD, MMSC,^d David Glineur, MD,^a Michel Vandyck, MD,^b Jean-Louis Vanoverschelde, MD, PhD,^c Philippe Noirhomme, MD,^a and Gebrine El Khoury, MD^a

Objectives: To assess root replacement and annular stabilization in bicuspid aortic valve repair, we compared results of reimplantation technique versus subcommissural annuloplasty or no annuloplasty.

Methods: Between 1995 and 2010, 161 consecutive patients underwent bicuspid aortic valve repair. Patients undergoing subcommissural annuloplasty or no annuloplasty (group 1, n = 87) had larger root dimensions and less aortic insufficiency than did patients undergoing reimplantation technique (group 2, n = 74). We matched groups 1 to 1 on basis of those criteria. After matching (n = 106, n = 53 per group), root dimensions (41.5 ± 5 vs 40 ± 4 mm; $P = .2$) and degree of insufficiency (2.6 ± 1.2 vs 2.7 ± 1 ; $P = .6$) were similar between groups.

Results: Techniques of cusp repair were similar between groups. Group 2 had smaller preoperative left ventricular size ($P = .02$), fewer concomitant procedures ($P = .02$), and shorter follow-up (41 ± 30 vs 63 ± 40 months; $P = .003$). There were no in-hospital deaths. At discharge, residual aortic insufficiency was similar between groups, but peak gradient greater than 25 mm Hg was more frequent in group 1 (13% vs 30%; $P = .04$). At 6 years, overall survival was $98\% \pm 3\%$ in both groups. Freedoms from reoperation and aortic insufficiency greater than 2+ were significantly better in group 2 (100% vs $90\% \pm 8\%$; $P = .03$; 100% vs $77\% \pm 14\%$; $P = .002$).

Conclusions: In bicuspid aortic valve repair, root replacement with the reimplantation technique stabilizes the ventriculoaortic junction, improves valve mobility (low gradient), and is associated with improved outcomes. (J Thorac Cardiovasc Surg 2011;142:1430-8)

Excellent results with BAV Repair **WITH** Re-implantation compared to other techniques

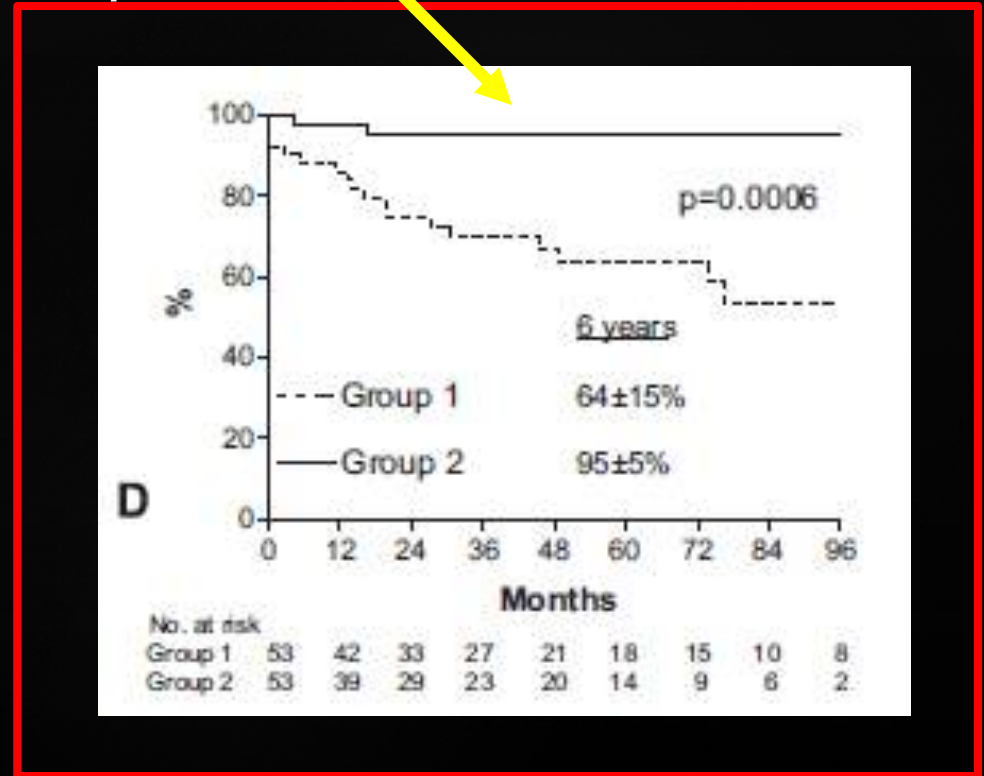
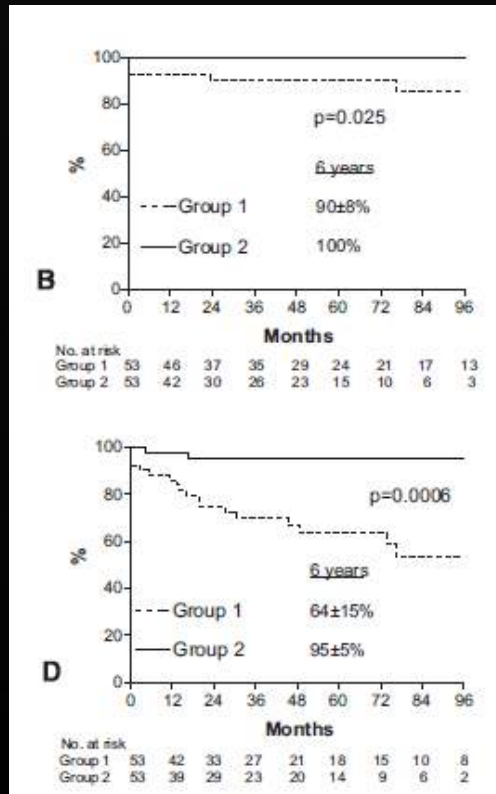


FIGURE 2. Kaplan-Meier actuarial survival curves comparing group 1 and group 2. A, Overall survival ($P = .9$). B, Freedom from aortic valve reoperation ($P = .025$). C, Freedom from recurrent aortic insufficiency greater than 2+ ($P = .002$). D, Freedom from recurrent aortic insufficiency greater than 1+ ($P = .0006$).

Winner of the 2012 EACTS Lillehei Award

Effect of annulus dimension and annuloplasty on bicuspid aortic valve repair[†]

Emiliano Navarra^a, Gebrine El Khoury^a, David Glineur^a, Munir Boodhwani^d, Michel Van Dyck^c,
Jean-Louis Vanoverschelde^b, Philippe Noirhomme^a and Laurent de Kerchove^{a,*}

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Abstract

OBJECTIVES: We have recently shown that valve sparing reimplantation (VSR) improves the durability of bicuspid aortic valve repair in comparison with subcommissural annuloplasty. The aim of this study was to assess the degree of annular reduction provided by these techniques and to correlate these findings with repair durability.

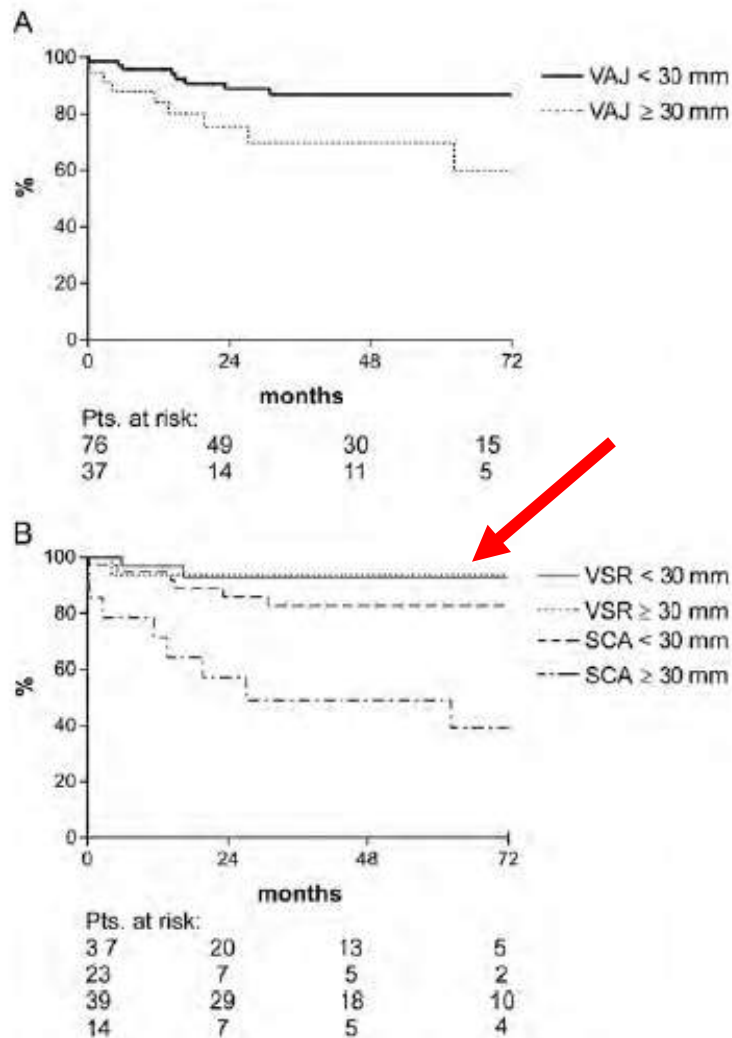
METHODS: From 1995 to 2010, 161 patients underwent bicuspid valve repair. We included only patients with subcommissural annuloplasty or reimplantation having intraoperative pre- and post-repair transoesophageal echocardiography images. Pre- and post-repair ventriculo-aortic junction (VAJ) diameters were measured on long axis views. Inclusion criteria were met by 53 patients with subcommissural annuloplasty and 65 with reimplantation. Median follow-up was 53 months in the subcommissural annuloplasty group and 42 months in the reimplantation group. Follow-up completeness was 100% in subcommissural annuloplasty and 94% in reimplantation.

RESULTS: There was no operative or late mortality. Mean preoperative VAJ was similar in both groups (reimplantation: 28 ± 3 mm vs subcommissural annuloplasty: 28 ± 3 , $P = 0.16$). Preoperative VAJ was larger in patients <40 years and with aortic regurgitation (AR) $\geq 3+$ ($P < 0.01$). Mean postoperative VAJ was smaller in reimplantation compared with subcommissural annuloplasty (21 ± 2 mm vs 24 ± 3 mm, $P < 0.01$). In univariate analyses, subcommissural annuloplasty, preoperative VAJ ≥ 30 mm, postoperative VAJ ≥ 25 mm and cusp repair with patch were predictive of recurrent AR $> 1+$. In the subcommissural annuloplasty group, VAJ ≥ 30 mm preoperatively and ≥ 25 mm postoperatively were associated with decreased 6 years freedom from recurrent AR $> 1+$ (<30 mm: 74% vs ≥ 30 mm: 39%, $P = 0.01$; <25 mm: 80% vs ≥ 25 mm 31%, $P = 0.02$). In the reimplantation group, VAJ dimension had no effect on recurrent AR $> 1+$ ($P = 0.93$).

CONCLUSIONS: In bicuspid aortic valve repair, the circumferential annuloplasty of VSR offers greater reduction of VAJ compared with the non-circumferential annuloplasty provided by the subcommissural annuloplasty. The degree and extent of VAJ reduction in reimplantation seem to be factors among others that positively influence repair durability particularly in patients with a large VAJ (≥ 30 mm).

Keywords: Bicuspid aortic valve • Aortic valve repair • Aortic root aneurysm • Valve regurgitation • Valve sparing surgery

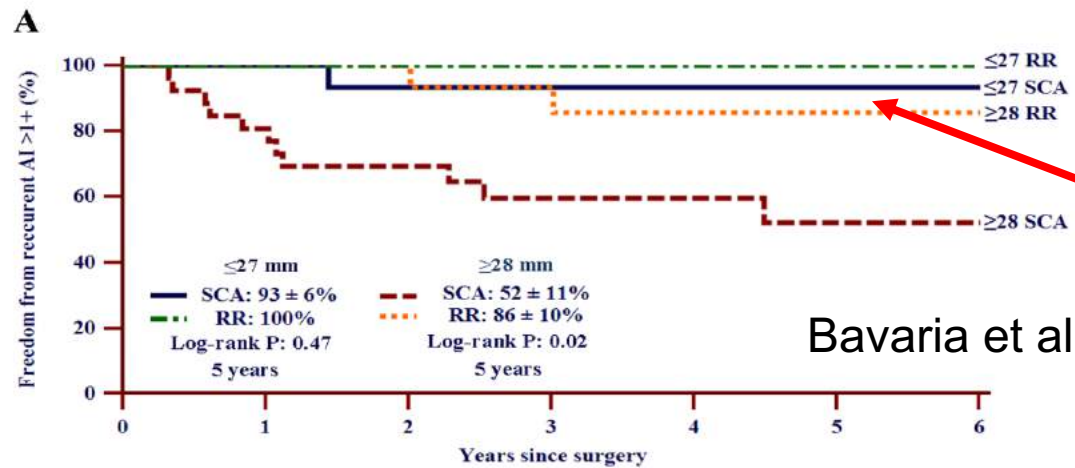




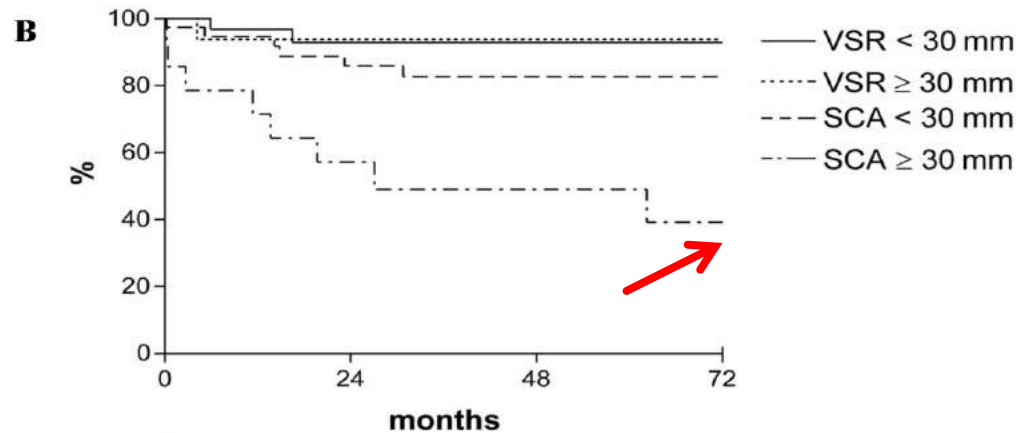
Excellent Results with Reimplantation procedure, regardless of pre-op annular dimension, with BAV Repair

Out to 6 years
2012 Publication

Figure 2: (A) Kaplan-Meier actuarial survival curves comparing freedom from recurrent AR>1+ on basis of preoperative ventriculoaortic junction (VAJ) diameter ≥ 30 mm in the entire cohort ($P = 0.03$). (B) Kaplan-Meier actuarial survival curves comparing freedom from recurrent AR>1+ on basis of preoperative ventriculoaortic junction (VAJ) diameter ≥ 30 mm in subcommisural annuloplasty (SCA) and valve sparing reimplantation (VSR) groups (SCA < 30 mm vs SCA ≥ 30 mm, $P = 0.01$; VSR < 30 mm vs VSR ≥ 30 mm, $P = 0.93$; SCA ≥ 30 mm vs VSR ≥ 30 mm, $P = 0.01$; SCA < 30 mm vs VSR < 30 mm, $P = 0.16$).



≤ 27 SCA: 16	16	11	9	5	2	2
≥ 28 SCA: 26	21	16	11	9	7	3
≥ 28 RR: 23	21	15	12	8	6	3
≤ 27 RR: 9	8	8	6	5	5	4



Pts. at risk:

37	20	13	5
23	7	5	2
39	29	18	10
14	7	5	4

G. El Khoury Brussels



SoWhat are the FUNDAMENTAL issues in BAV Valve Repair at this time?

- Whether ALL BAV repairs should be done with a DV (or Root) procedure OR (VS) Whether those patients with a Sinus diameter <45 mm (or 40 mm for certain subgroups) should receive an Aortic **RING ANNULOPLASTY** with BAV repair. What's the DATA??
- And , a lesser **TECHNICAL** issue: Whether All BAV repair cases should be forced into a 180 Annular/Commissure configuration or should the Commissural angles be respected?

Tirone David valve-sparing aortic root replacement and cusp repair for bicuspid aortic valve disease

Fabian A. Kari, MD,^a David H. Liang, MD, PhD,^b John-Peder Escobar Kvitting, MD, PhD,^a Elizabeth H. Stephens, MD, PhD,^a R. Scott Mitchell, MD,^a Michael P. Fischbein, MD, PhD,^a and D. Craig Miller, MD^a

Objectives: The durability of valve-sparing aortic root replacement with or without cusp repair in patients with bicuspid aortic valve (BAV) disease is questioned. We analyzed the results of 75 patients with a BAV undergoing Tirone David reimplantation valve-sparing aortic root replacement.

Methods: Average age was 45 ± 10 years; 80% were male; 31% had 2+ or greater aortic regurgitation (AR); annular diameter averaged 28 ± 3 mm; 32% had a Sievers' type 0 BAV, and 66% underwent concomitant cusp repair (usually cusp free margin shortening) to correct prolapse. Early (6 ± 3 days) and late (2.9 ± 1.7 , 1-10 years) postoperative echocardiographic results were compared (cumulative echocardiographic follow-up, 190 patient-years; median late interval, 2 years [interquartile range, 0.68, 4.2]). Seven patients remained at risk beyond 6 years. Clinical outcome and valve function were analyzed using log-rank calculations.

Results: Actuarial survival was $99\% \pm 2\%$; freedom from reoperation was $90\% \pm 5\%$, infection $98\% \pm 2\%$, and stroke 100% at 6 years. After initial improvement in degree of AR ($P < .001$), minor subclinical progression of AR was observed ($P > .5$); however, freedom from AR of more than 2+ was 100%. Cusp free margin shortening was not associated with valve deterioration, but commissural suspensory polytetrafluoroethylene neo-chord creation ($n = 4$) portended a higher probability of recurrent AR ($P = .025$).

Conclusions: After David procedure and cusp repair in patients with a BAV, midterm clinical and valve function outcomes were favorable out to 6 years. More follow-up is required to determine long-term valve durability and the hazard of other clinically important late adverse events, including eventual reoperation, to beyond 10 years. (J Thorac Cardiovasc Surg 2013;145:S35-40)

Summary/ Interesting or Distinctive Points

- 100% reimplantation; Large expert series (2013); very conservative
 - Avg age = 45
 - 6 year freedom from reop = 90%
- All patients had significant Annular Stabilization
 - Via the Re-implantation
- Only 31% had +2 or greater PRE-OP AI
- All were ROOT procedures

Tirone David valve-sparing aortic root replacement and cusp repair for bicuspid aortic valve disease

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METHODS

- Free margin shortening was major technique used for cusp repair
- Perforated cusps were replaced – **NO PATCH repair**
- BAV presenting with dilated aortic annulus underwent valve-sparing root reimplantation regardless of root aneurysm size (**NOT Subcommissural Annuloplasty**)
- Avoid triangular raphe resection and cusp plication to **reduce risk of impaired cusp mobility**

“If the 2 fused cusps are thin, not excessively prolapsing, and the raphe is not densely fibrotic or calcified, free margin shortening is usually adequate.”

Tirone David valve-sparing aortic root replacement and cusp repair for bicuspid aortic valve disease

Fabian A. Kari, MD,^a David H. Liang, MD, PhD,^b John-Peder Escobar Kvitting, MD, PhD,^a Elizabeth H. Stephens, MD, PhD,^a R. Scott Mitchell, MD,^a Michael P. Fischbein, MD, PhD,^a and D. Craig Miller, MD^a

Results: Actuarial survival was 99% \pm 2%; freedom from reoperation was 90% \pm 5%, infection 98% \pm 2%, and stroke 100% at 6 years. After initial improvement in degree of AR ($P < .001$), minor subclinical progression of AR was observed ($P > .5$); however, freedom from AR of more than 2+ was 100%. Cusp free margin shortening was not associated with valve deterioration, but commissural suspensory polytetrafluoroethylene neo-chord creation ($n = 4$) portended a higher probability of recurrent AR ($P = .025$).

- 73 BAV patients underwent valve-sparing root reimplantation
- 66% had concomitant cusp repair
- Excellent results at 6 years: freedom from reoperation: 90 \pm 5%,
freedom from AI >2+: 100%

METHODS describe evolution of BAV repair technique and surgical strategy aimed to mitigate risk of early and late failure resulting in recurrent AI and/or reoperation

From Emory Group (2017); N=223; 52/223 had BAV

Severity of Preoperative Aortic Regurgitation Does Not Impact Valve Durability of Aortic Valve Repair Following the David V Valve Sparing Aortic Root Replacement



W. Brent Keeling, MD, Bradley G. Leshnower, MD, Jose Binongo, PhD, Yi Lasanajak, MSPH, LaRonica McPherson, RN, and Edward P. Chen, MD

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Background. The David V valve-sparing aortic root replacement (VSRR) is an established and durable method of root reconstruction for varying pathologies. However, the impact of the severity of preoperative aortic regurgitation (AR) on long-term durability remains unclear. The purpose of this research was to investigate the impact of the degree of preoperative AR on midterm durability following VSRR.

Methods. A retrospective review of the adult cardiac surgical database at a single academic center was undertaken from 2005 to 2015 for 223 adult patients who underwent VSRR. Patients were followed annually with echocardiograms, and a prospectively maintained database kept track of patient data. Follow-up was 97.7% complete, and the median echocardiographic follow-up was 25.5 months (range, 1 to 123 months). Patients with preoperative AR less than or equal to 2 were compared with patients with AR greater than 2 to determine the impact of preoperative AR upon valve repair durability.

Results. There were 223 patients who underwent VSRR during the study period, including 114 (51.1%) who required concomitant cusp repair. The operative mortality was 5 (2.2%). Ninety-seven patients (43.5%) had preoperative AR greater than 2. A total of 213 patients (95.5%) were

available for long-term follow-up; of these patients, 7 (3.3%) had AR greater than 2. Fifty-two patients had a bicuspid aortic valve (22 AR ≤ 2 and 30 AR > 2 ; $p = 0.02$). Patients with preoperative AR greater than 2 experienced greater reverse left ventricular remodeling and increases in left ventricular ejection fraction than did patients with preoperative AR less than or equal to 2 ($p < 0.01$). The midterm freedom from AR greater than 2 was similar for both preoperative AR groups ($p = 0.57$). The 8-year freedom from AR greater than 2 was 89.1% (95% confidence interval, 55.3% to 97.8%) for patients with preoperative AR less than or equal to 2 and 92.7% (95% confidence interval, 78.8% to 97.6%) for preoperative AR greater than 2. Five patients (2.4%) required aortic valve replacement during the follow-up period (3 preoperative AR ≤ 2 , 2 preoperative AR > 2).

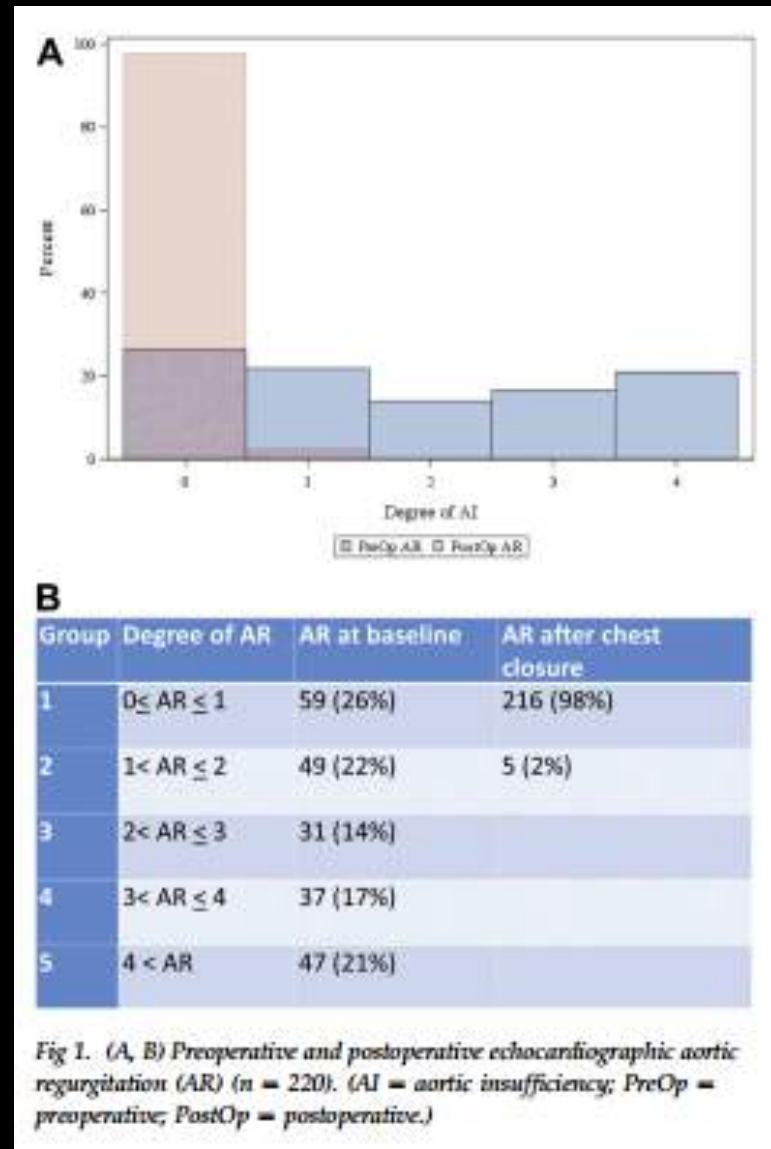
Conclusions. VSRR remains an effective and durable treatment for severe AR and preserved leaflet architecture. The severity of preoperative AR does not appear to impact midterm freedom from moderate to severe AR. VSRR results in significant left ventricular remodeling in patients with preoperative AR greater than 2.

(Ann Thorac Surg 2017;103:756–63)

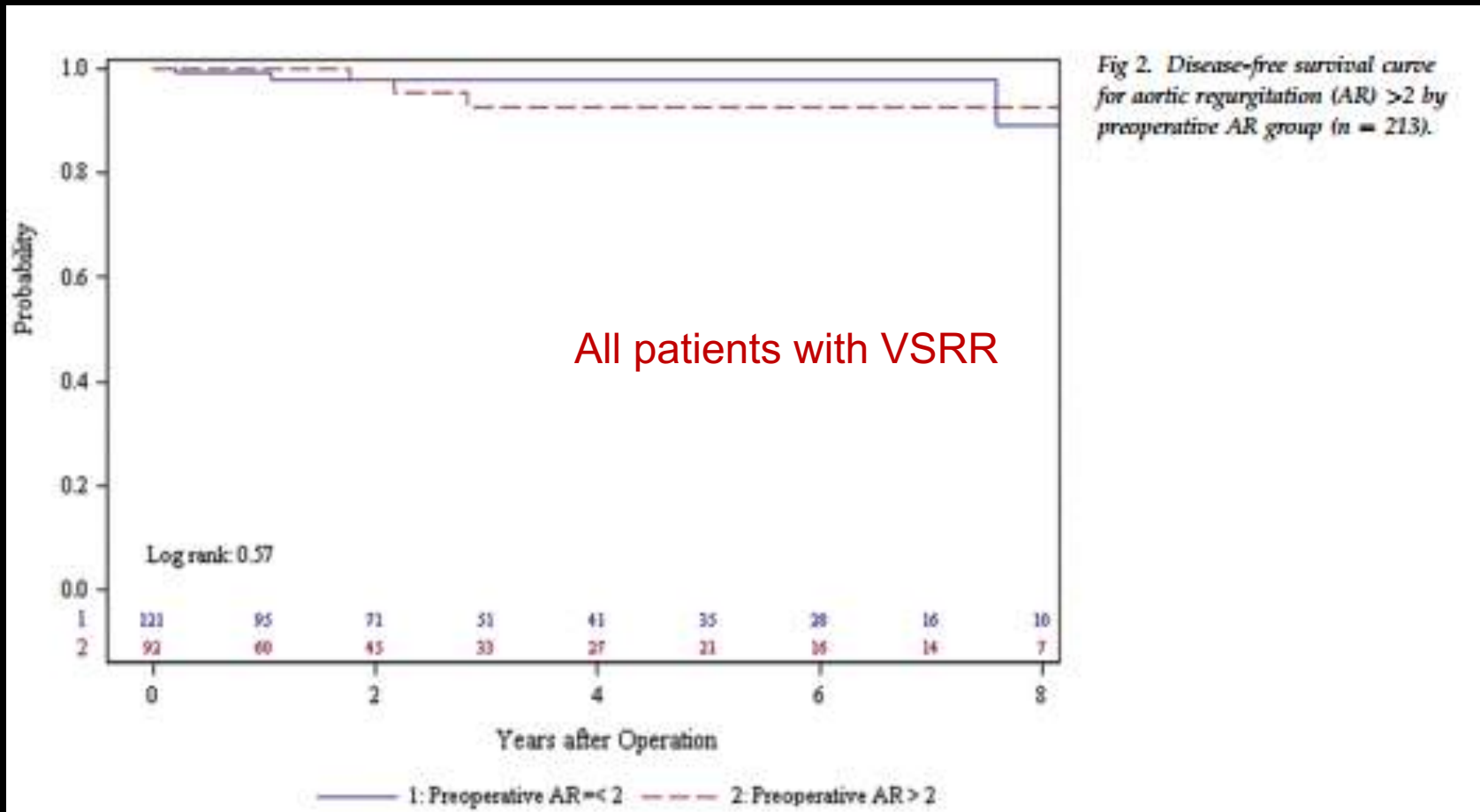
© 2017 by The Society of Thoracic Surgeons

Despite a > 50% Cusp Repair rate overall and a > **70% Cusp repair for BAV**, The AR result was Good

Note: In the Penn Series= 100% of Sievers 1 BAV had cusp repair



Preop AR grade had no effect on Mid-Term (6-7 year) outcomes regarding development of $>+2$ AI (52/223 had BAV VSRR)



What about AI?



Penn BAV Series Data

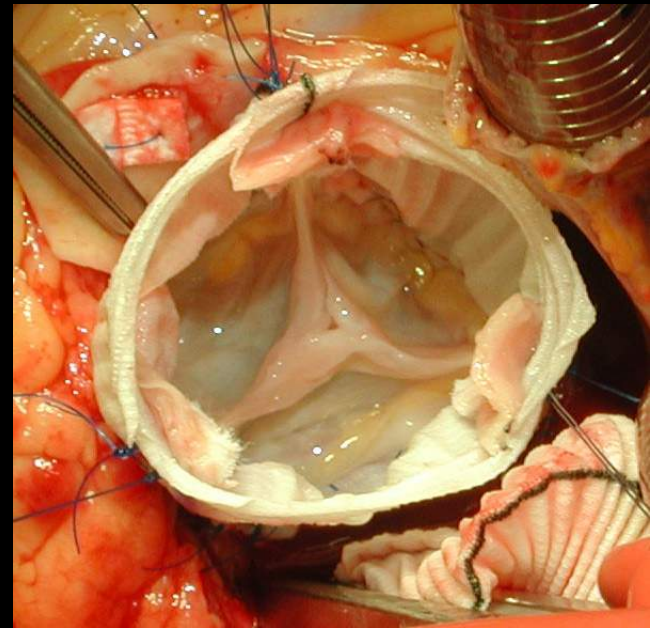
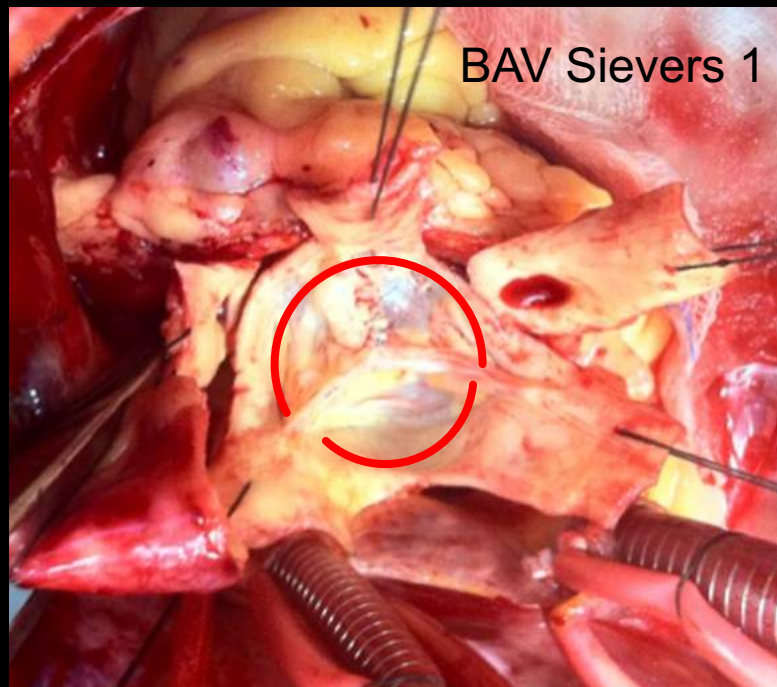
BAV vs TAV

BAV VSRR vs other techniques

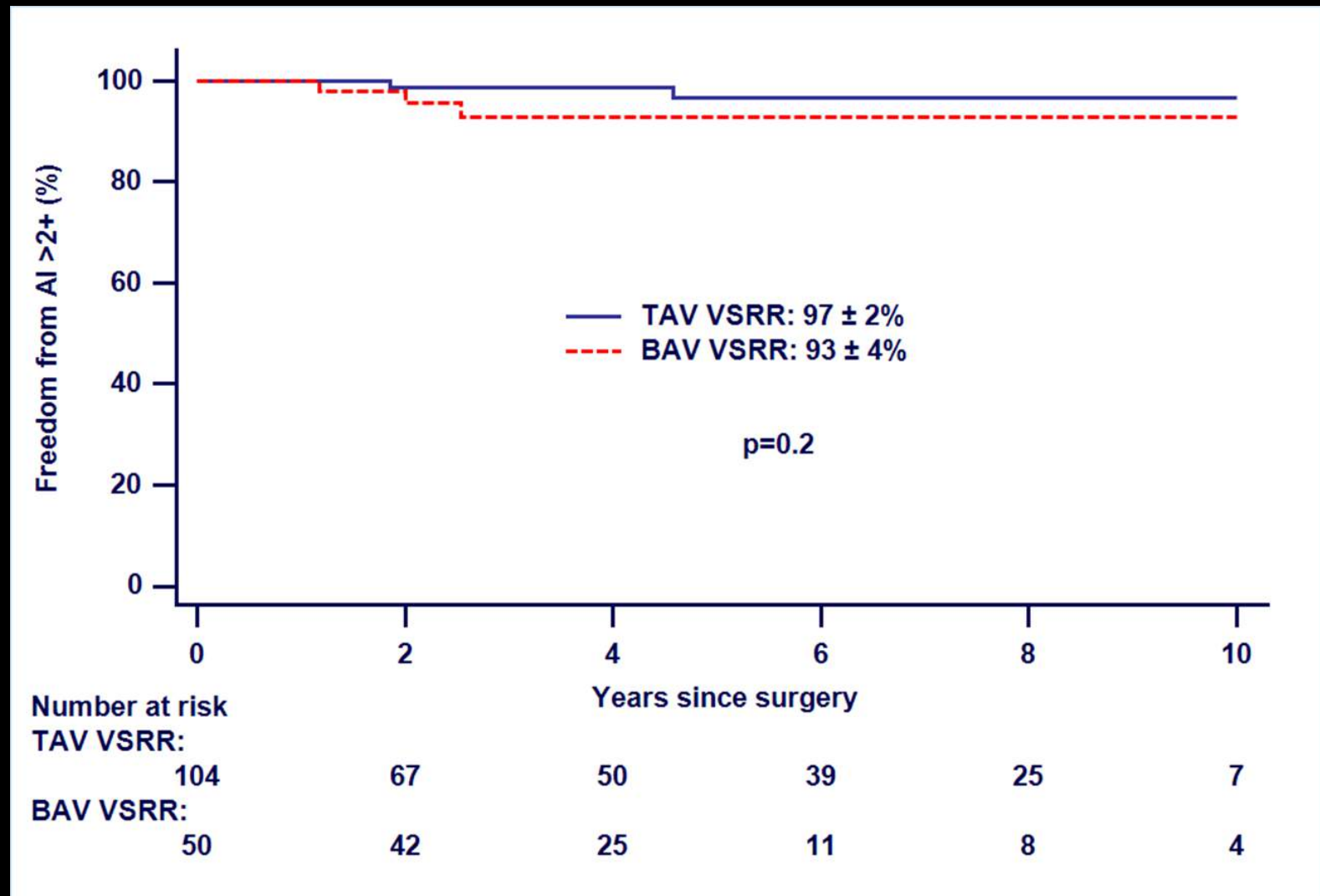
BAV VSRR vs (matched) Composite Graft Bentall

Outcomes with BAV Repair + Root Reimplantation:

How do they compare to our institutional tricuspid aortic valve root reimplantation?

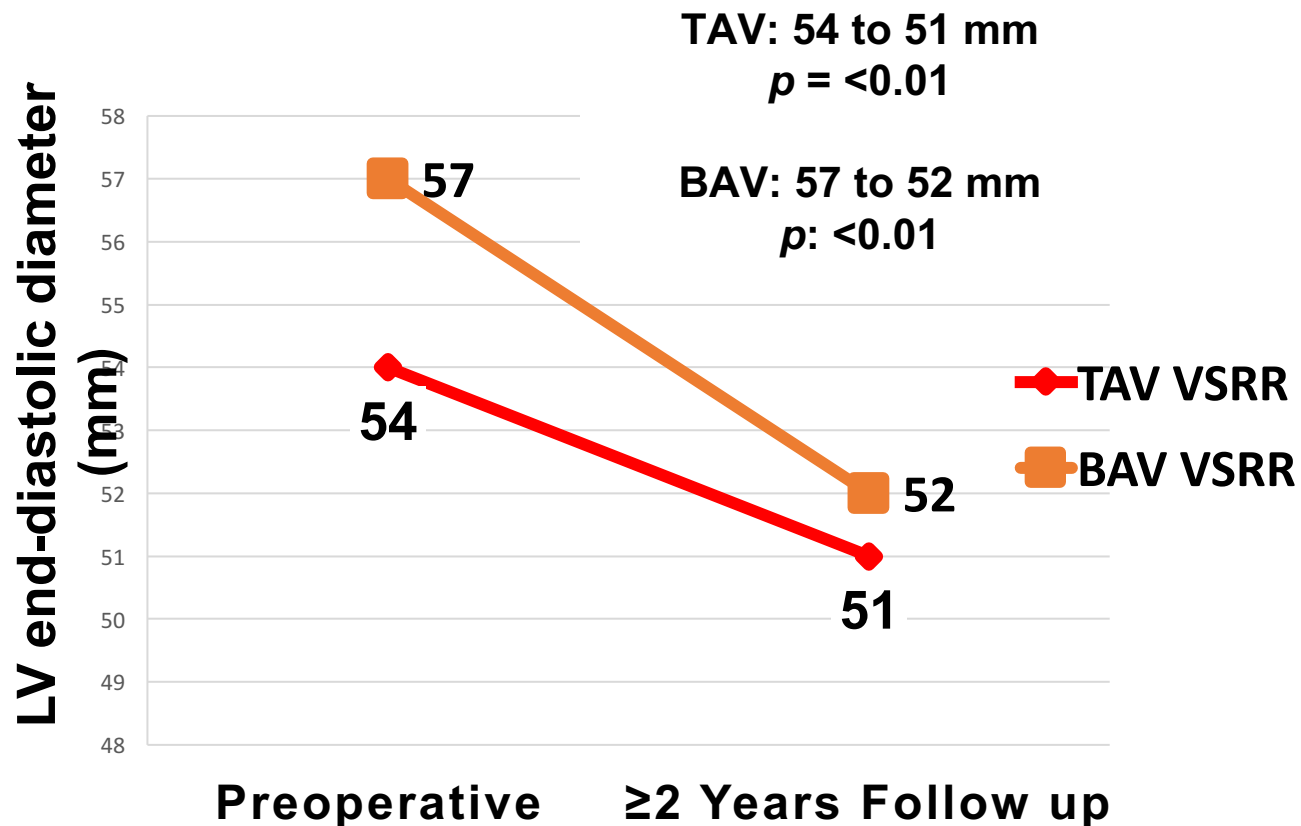


Freedom from AI >2+ (%) (100% of BAV VSRR had Leaflet Repair)

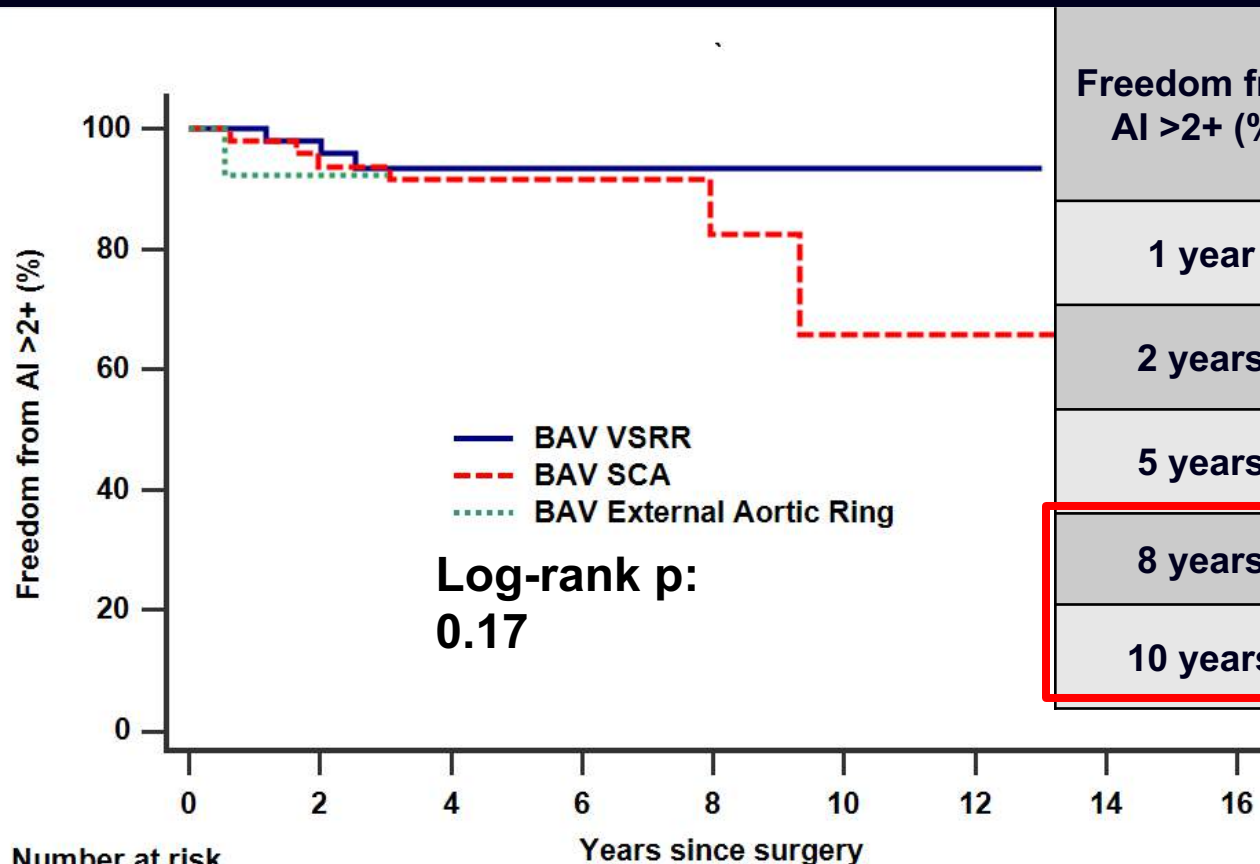


Data thru 4/2016; partial update 2016; Bavaria, et al; JTCVS 2014

LV Remodeling: Excellent in Both groups



Freedom from AI > +2 (Mod or Severe) DV compared to Subannular Techniques



Freedom from AI >+2 (%)	BAV VSRR	BAV SCA	BAV External Annular Ring
1 year	100%	98 ± 2%	92 ± 7%
2 years	98 ± 2%	94 ± 3%	92 ± 7%
5 years	94 ± 4%	92 ± 4%	NA
8 years	94 ± 4%	82 ± 9%	NA
10 years	94 ± 4%	66 ± 17%	NA

Number at risk

BAV VSRR

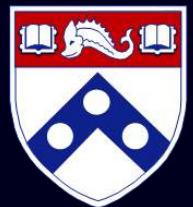
56 46 27 12 9 5 2 0 0

BAV SCA

51 44 37 18 8 4 3 1 0

BAV External Aortic Ring

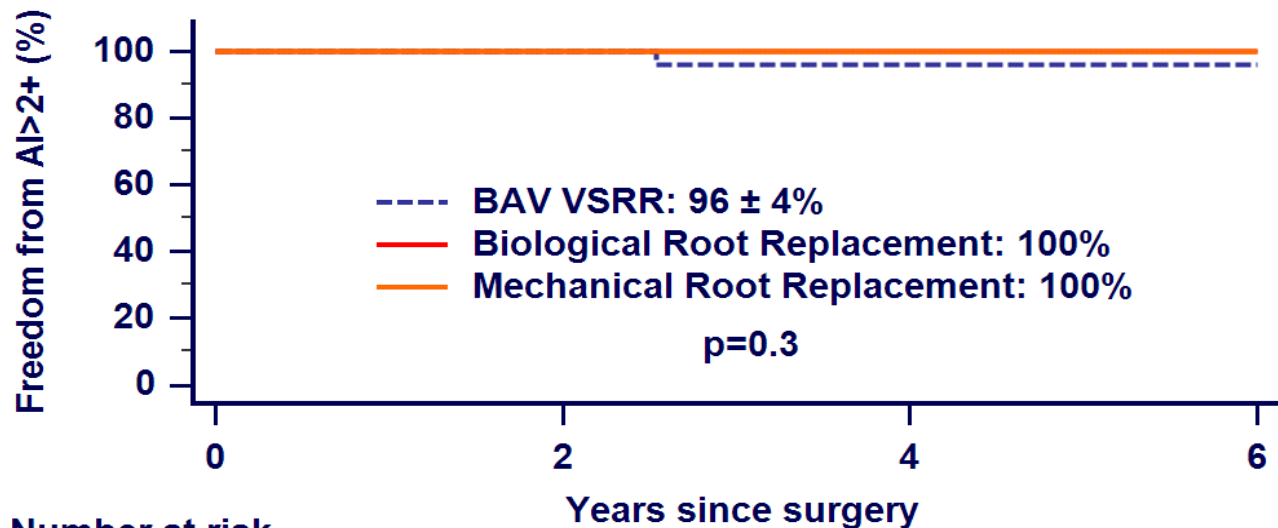
27 3 0 0 0 0 0 0 0



BAV Root Operations with AI:

Comparison of Bentall Root Procedures vs Reimplantation BAV Repair (100% repair)

5C



Number at risk

BAV VSRR:

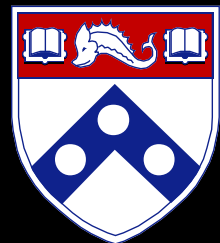
Years since surgery	0	2	4	6
BAV VSRR:	45	29	14	10
Biological Root Replacement:	35	35	34	31
Mechanical Root Replacement:	85	79	74	45

Biological Root Replacement:

35 35 34 31

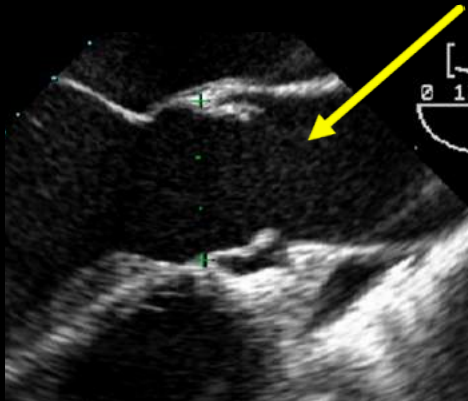
Mechanical Root Replacement:

85 79 74 45

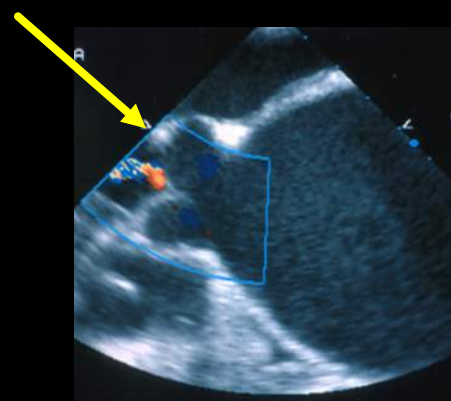


SoWhat are the FUNDAMENTAL issues in BAV Valve Repair at this time?

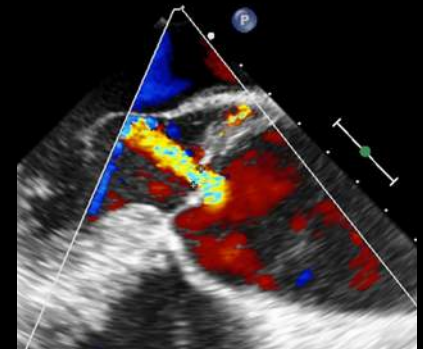
- Whether ALL BAV repairs should be done with a DV (or Root) procedure OR (VS) Whether those patients with a Sinus diameter <45 mm (or 40 mm for certain subgroups) should receive an Aortic **RING ANNULOPLASTY** with BAV repair. What's the DATA??
 - I'm Still not sure??
 - The best AV Repair is a Root!?



VS



VS



Conclusions: Bicuspid Aortic Valve Repair with Reimplantation

- BAV repair with Reimplantation is very feasible with very good mid-term outcomes (8-10 years)
 - With minimal leaflet Calcification
 - Either 210/150 or 180/180 orientation is reasonable depending on pre-operative perimeter assessment
- Annular Stabilization is Critical
- Re-Implantation (or Sub-annular Ring) accomplishes this stabilization goal.
- Simple SCA in pre-op Annular diameters >27 should be abandoned
- Reconstructive principles need to be vigorously upheld

Thomas Eakins: Gross Clinic (1878@JEFF) and Agnew Clinic (1888@PENN)

Great Progress in 10 years!

Danke für Ihre Aufmerksamkeit



What is the FUNDAMENTAL issue in BAV Valve Repair at this time?

- Whether ALL BAV repairs should be done with a DV (or Root) procedure OR (VS) Whether those patients with a Sinus diameter <45 mm (or 40 mm for certain subgroups) should receive an Aortic **RING ANNULOPLASTY** with BAV repair. What's the DATA??

SoWhat are the FUNDAMENTAL issues in BAV Valve Repair at this time?

- Whether ALL BAV repairs should be done with a DV (or Root) procedure OR (VS) Whether those patients with a Sinus diameter <45 mm (or 40 mm for certain subgroups) should receive an Aortic **RING ANNULOPLASTY** with BAV repair. What's the DATA??
 - I'm Still not sure??
- And , a lesser **TECHNICAL** issue: Whether All BAV repair cases should be forced into a 180 Annular/Commissure configuration or should the Commissural angles be respected?
 - I believe that 180 or 210 works fine so I respect geometry