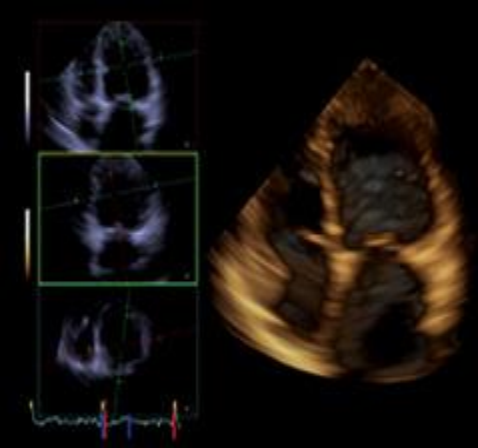


EuroValve

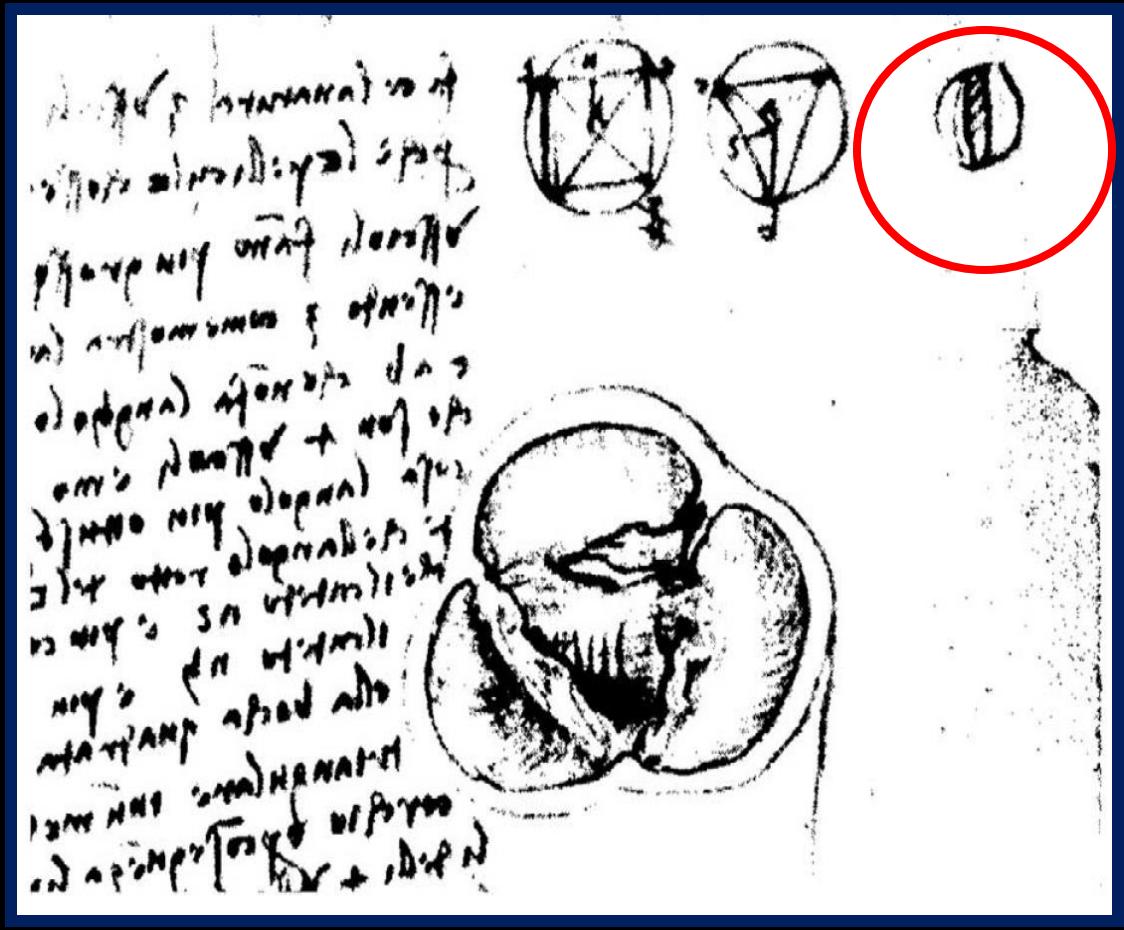
November 8-9, 2013 • Madrid, Spain

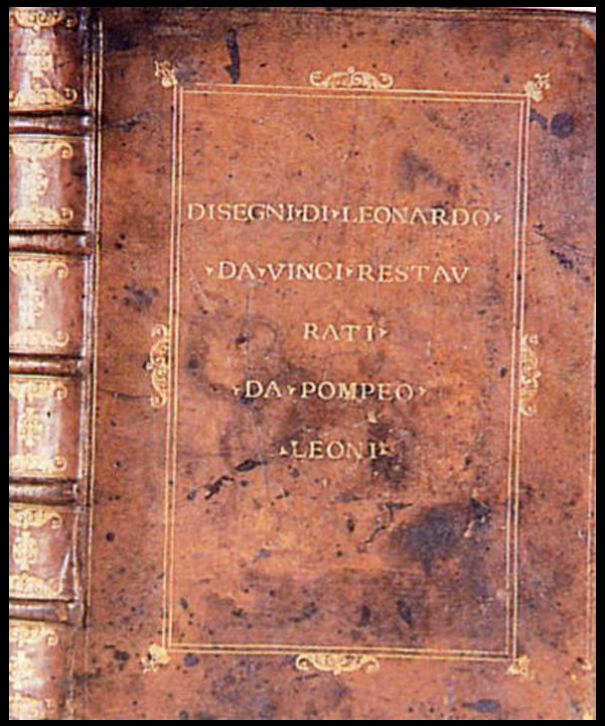
Bicuspide Aortic Valve Repair

Khalil Fattouch, MD, PhD.
GVM Care and Research, MEH, Palermo

History

The earliest description of the BAV has been attributed to Leonardo Da Vinci who over 400 years ago sketched the bicuspid variant of the aortic valve.





Corpus of the anatomical studies

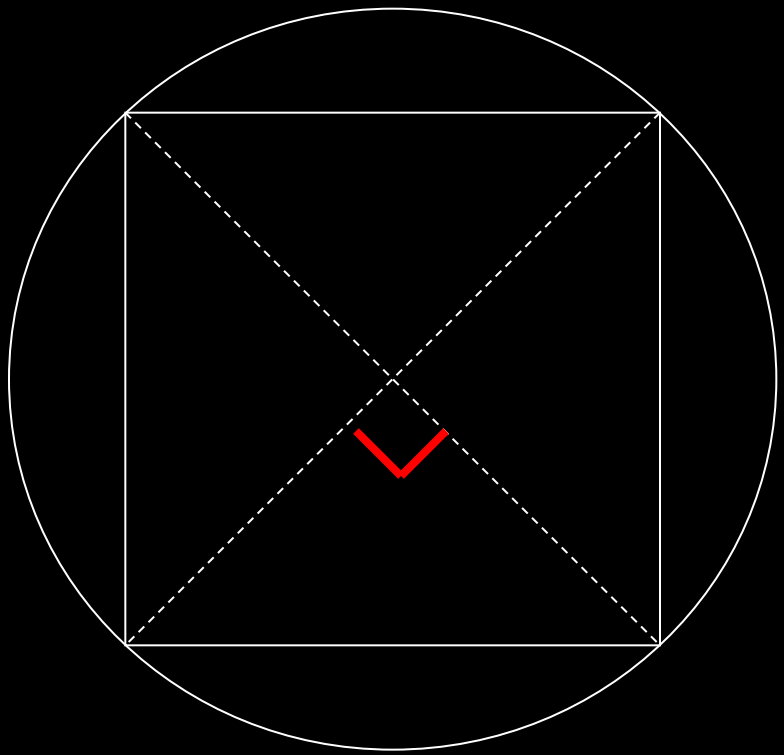
"In the collection of Her Majesty the Queen at Windsor Castle"

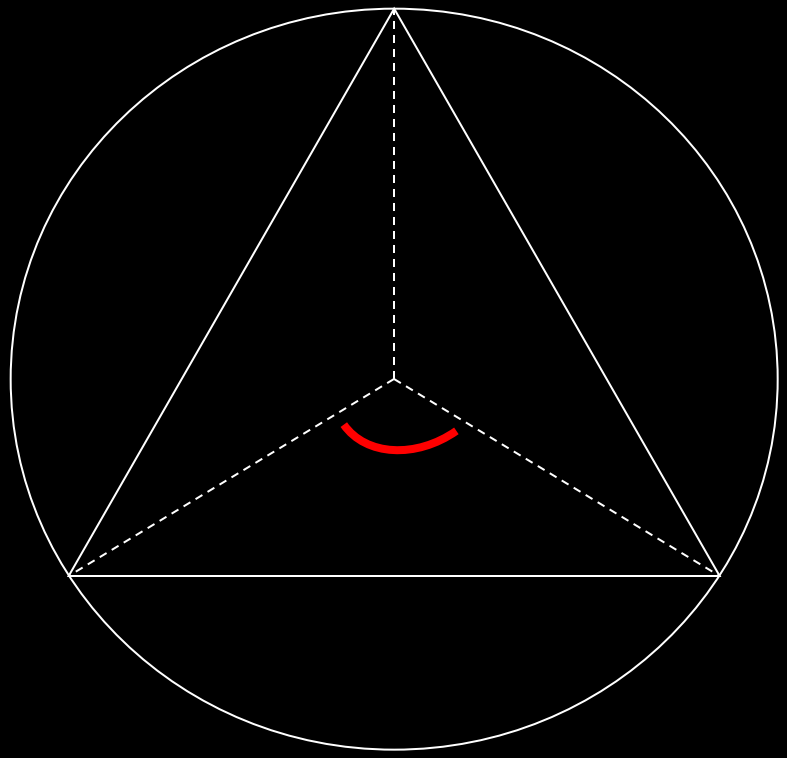
“why the orifice of the aortic artery is triangular”

“perche il buso della arteria aorto e trianghulare”

(Leonardo Da Vinci)

“the more obtuse angle is stronger than the right angle of the square”

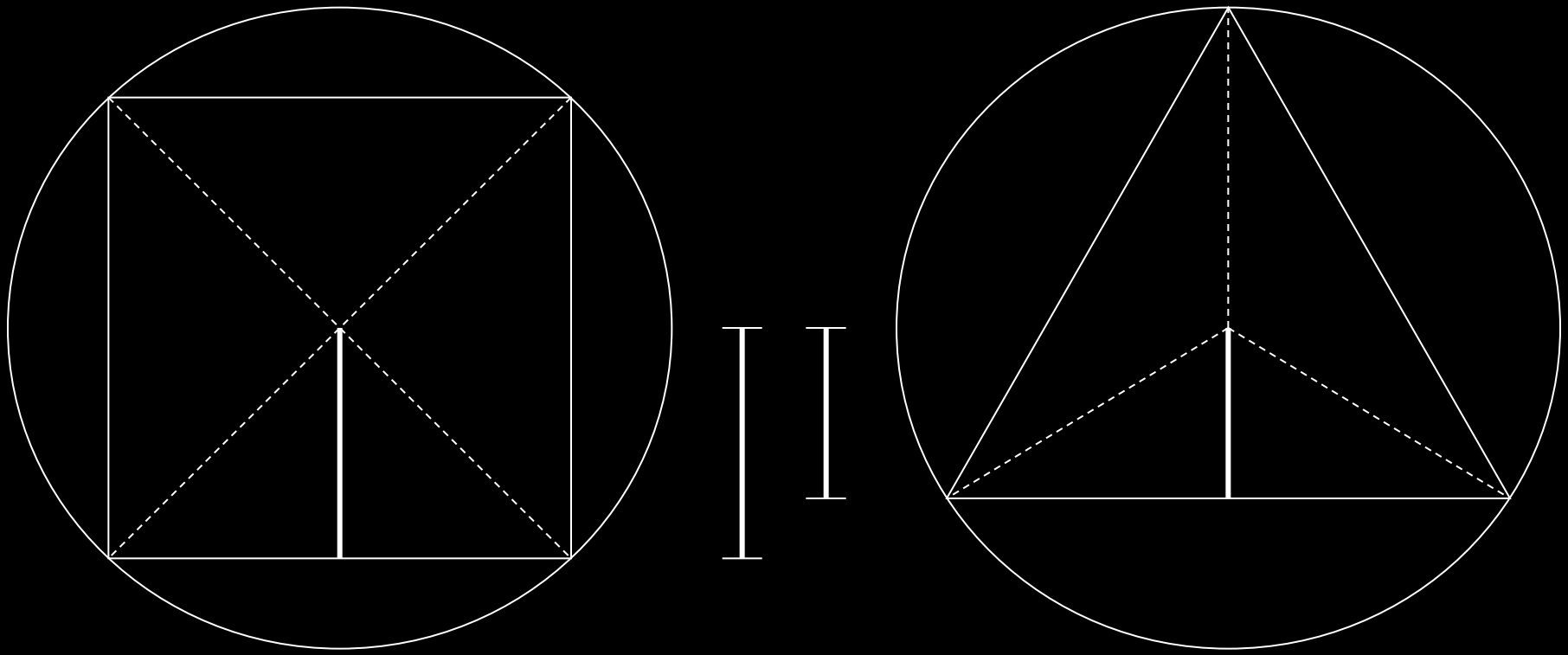




“per la qual cosa l’angolo piu ottuso e piu forte chellangolo retto ”

(Leonardo Da Vinci)

“the membranes of four valve-cusps are weaker than those of three valve-cusps because their central radius are more high”

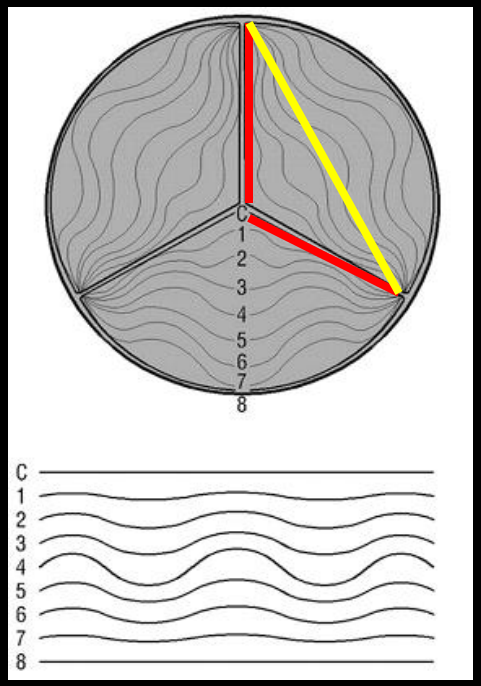


”i panniculi delli 4 usscoli son piu deboli che li 3 usscioli perche colli loro angholi son piu remoti dalla basa del triangolo loro che quel de 3 usscioli”

Functional Geometry of the aortic valve

The total length of the cusps free edge:

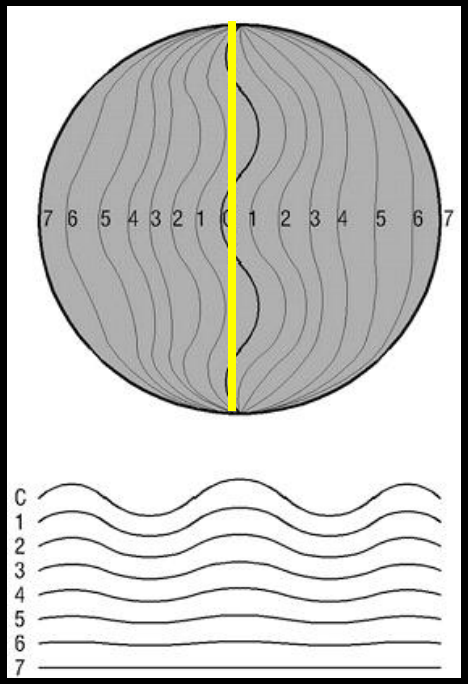
equal to the circumference
more than the intercomissural distance



It allows:

Complete opening with circular orifice

Wrinkle-Slow closure during dyastole

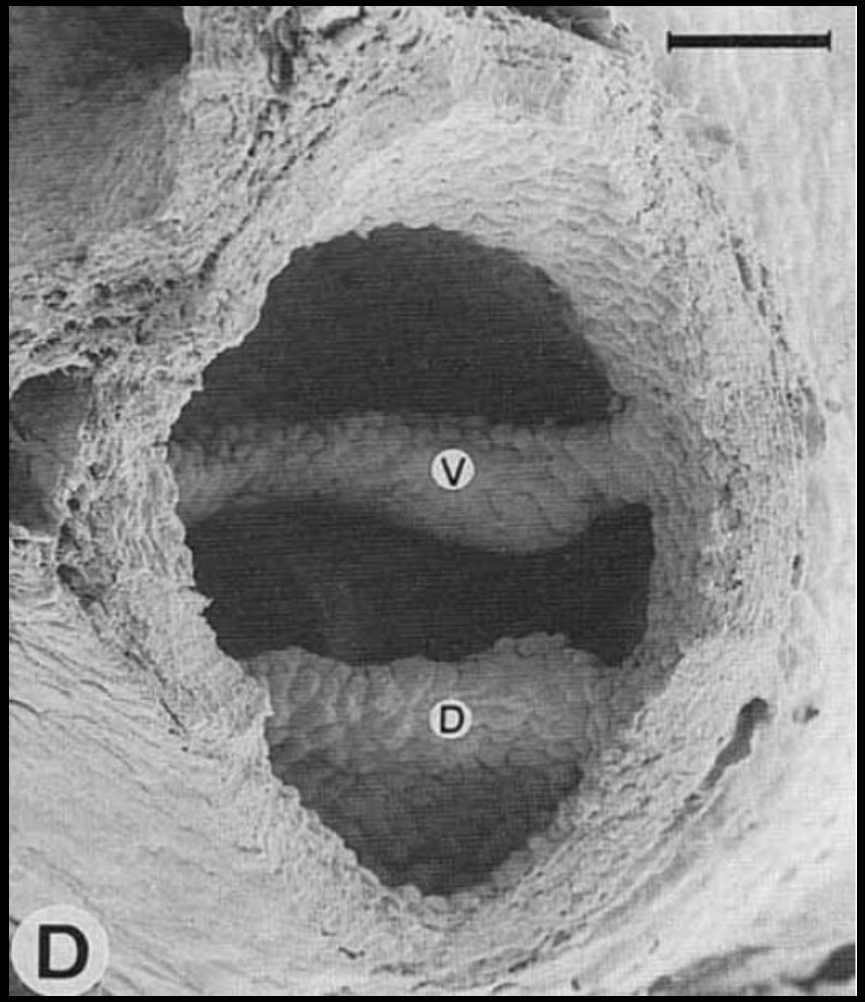


Tricuspid

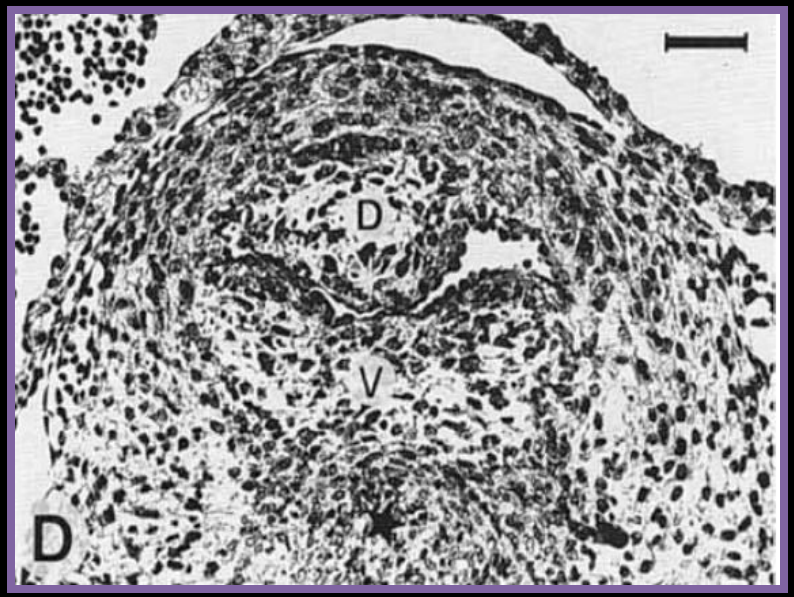
Bicuspid

Robicsek, F. et al.; Ann Thorac Surg 2004;77:177-185

Embryology of bicuspid aortic valve
Type 0 (no raphe)

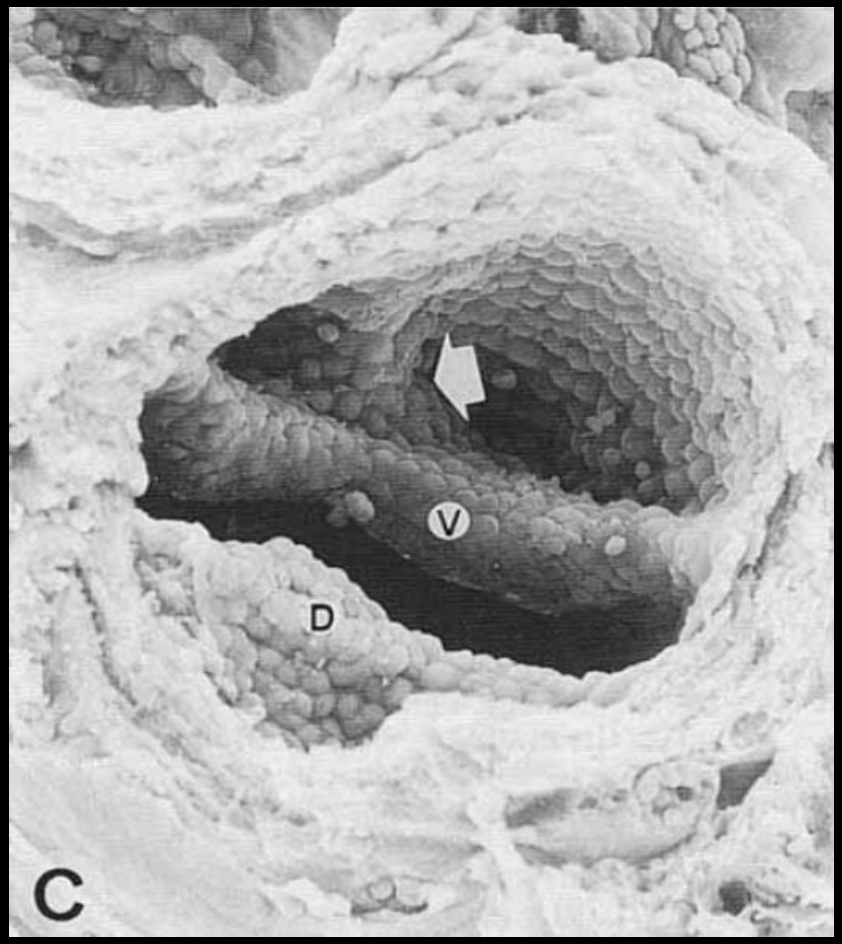


The ventral cushion results from the complete fusion of the right and left cushions

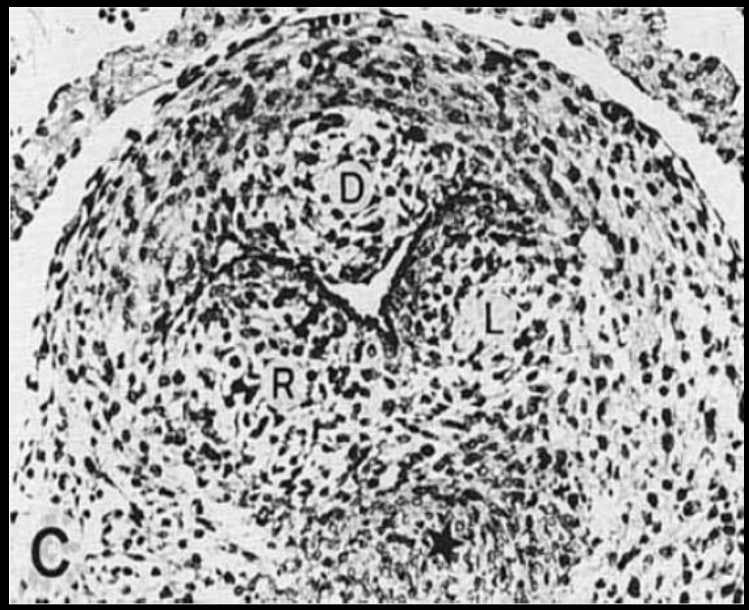


THE ANATOMICAL RECORD 244:490-498 (1996)

Embryology of bicuspid aortic valve
Type 1 (one raphe, partial fusion)

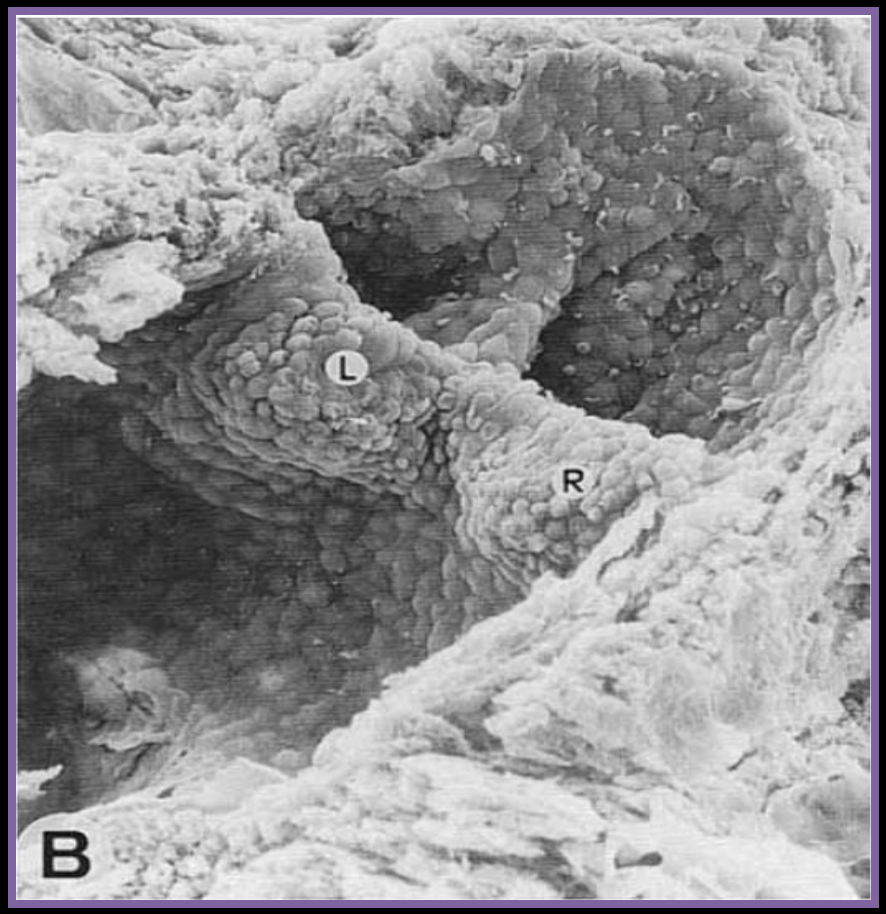


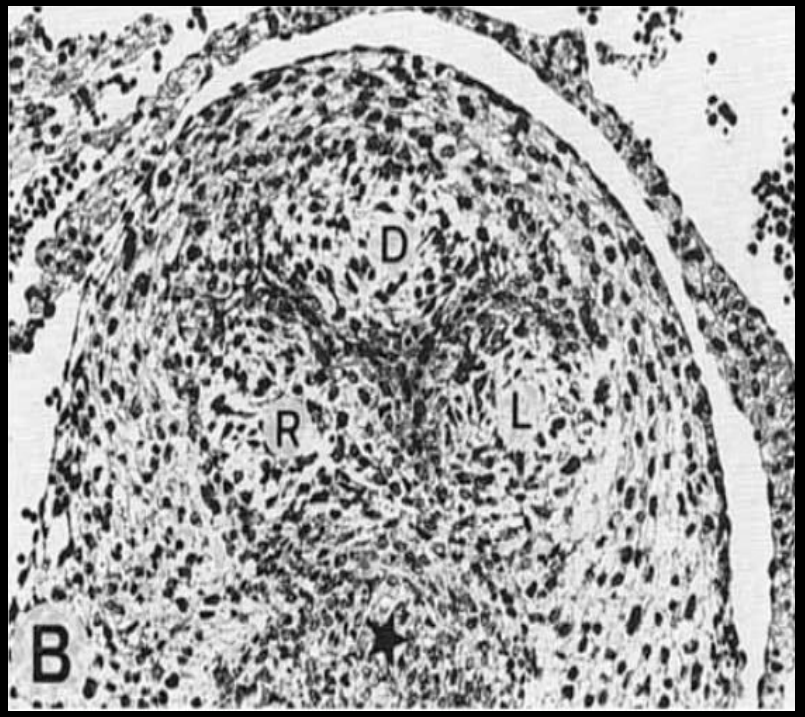
The ridge (arrow) located in the ventral aortic sinus outlines a future raphe (pseudo-bicuspide valve)



THE ANATOMICAL RECORD 244:490-498 (1996)

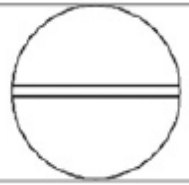
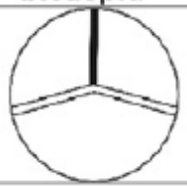
Embryology of Bicuspid aortic valve
Type 2 (total fusion, Fibrotic 1 o 2 Rafe)





THE ANATOMICAL RECORD 244:490-498 (1996)

Classification of the Bicuspid valve

Commonly used terms		quadricuspid	tricuspid	bicuspid		
Scheme of morphological appearance						
functional characteristics	No of cusps	4	3	2	2	2
morphological characteristics	No of raphes	0	0	0	1	2
	No of cusps	4	3	purely bicuspid* 2	potentially tricuspid* 3 anlagen, (2 under- and 1 fully developed)	3 anlagen, (2 under- and 1 fully developed)
	Size of cusps	non-equal	equal	equal	non-equal	non-equal
	No of commissures	4	3	2	1 under- and 2 fully developed	2 under- and 1 fully developed

Sievers H, et al. *J Thorac Cardiovasc Surg 2007;133:1226-33*

Bicuspid aortic valve: differences in the phenotypic continuum affect the repair technique☆

Andrea Mangini*, Massimo Lemma, Monica Contino, Matteo Pettinari, Guido Gelpi, Carlo Antona

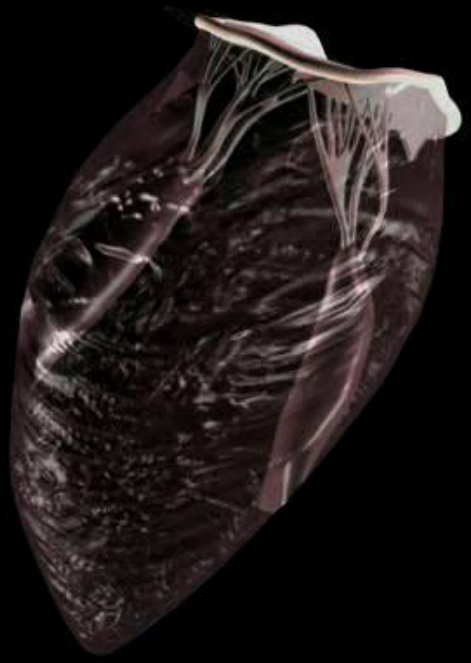
The surgical techniques should be applied after a careful analysis of the BAV considered in the context of the phenotypic continuum.

European Journal of Cardio-thoracic Surgery xxx (2010) xxx–xxx

Aortic valve repair

What we learn from the mitral valve?

… isn't a valve with 2 leaflets …, but a complex functional apparatus



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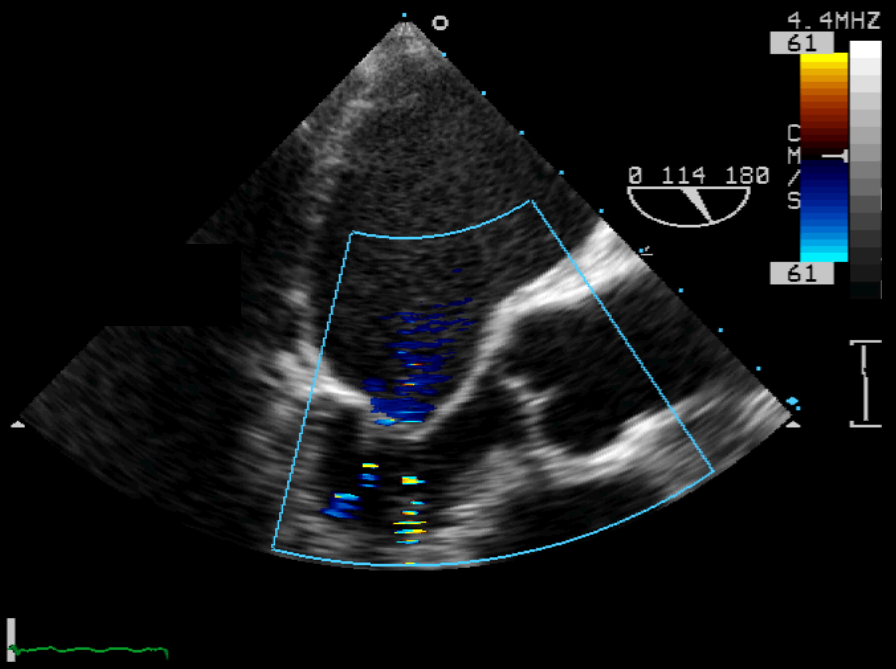
The Aortic Valve

Isn’t a valve with leaflets …, but a complex functional unit

- Aortic Anulus
- Cusps
- Valsalva sinuses
- Commissures
- Sino-tubular Junction
- Ascending aorta



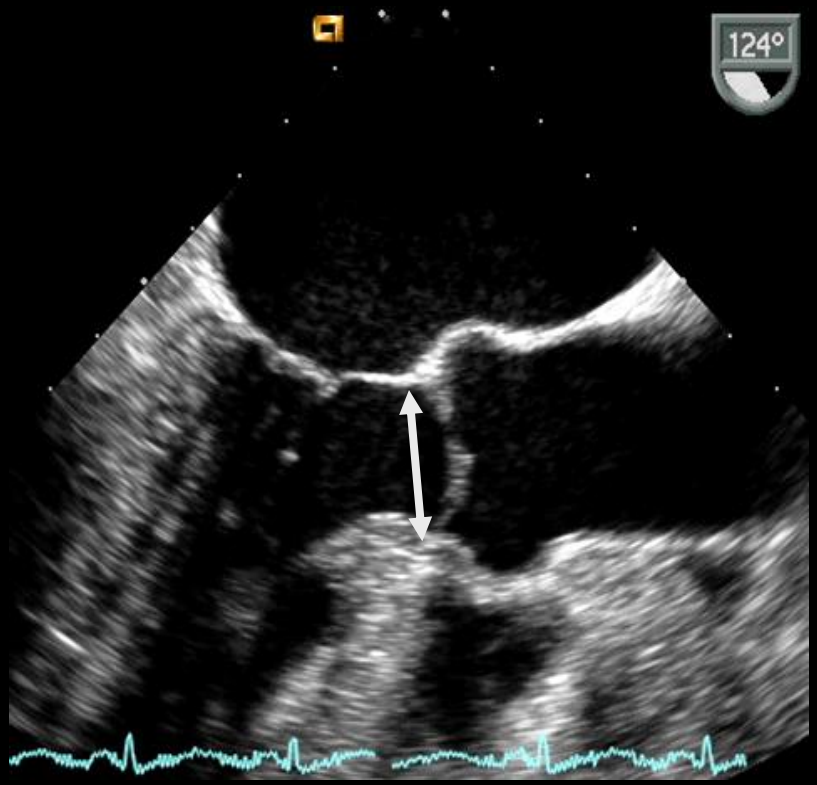
Bicuspid Valve Repair
First lesson from mitral valve repair

Anuluplasty is a fundamental step in valve repair:

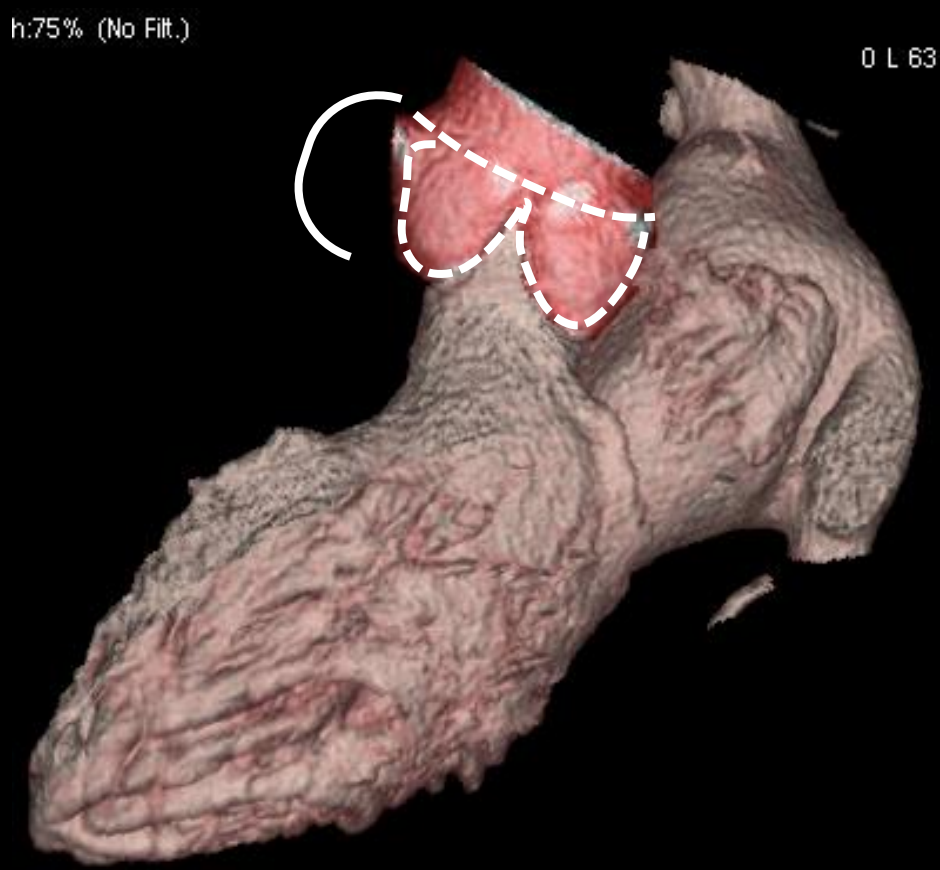
- Re-shape the anulus (FAA)
- Stabilize the repair
  (continuity between the nadir and the STJ)
- Improve Leaflets coaptation (subcommissural plasty)

Aortic annulus ?

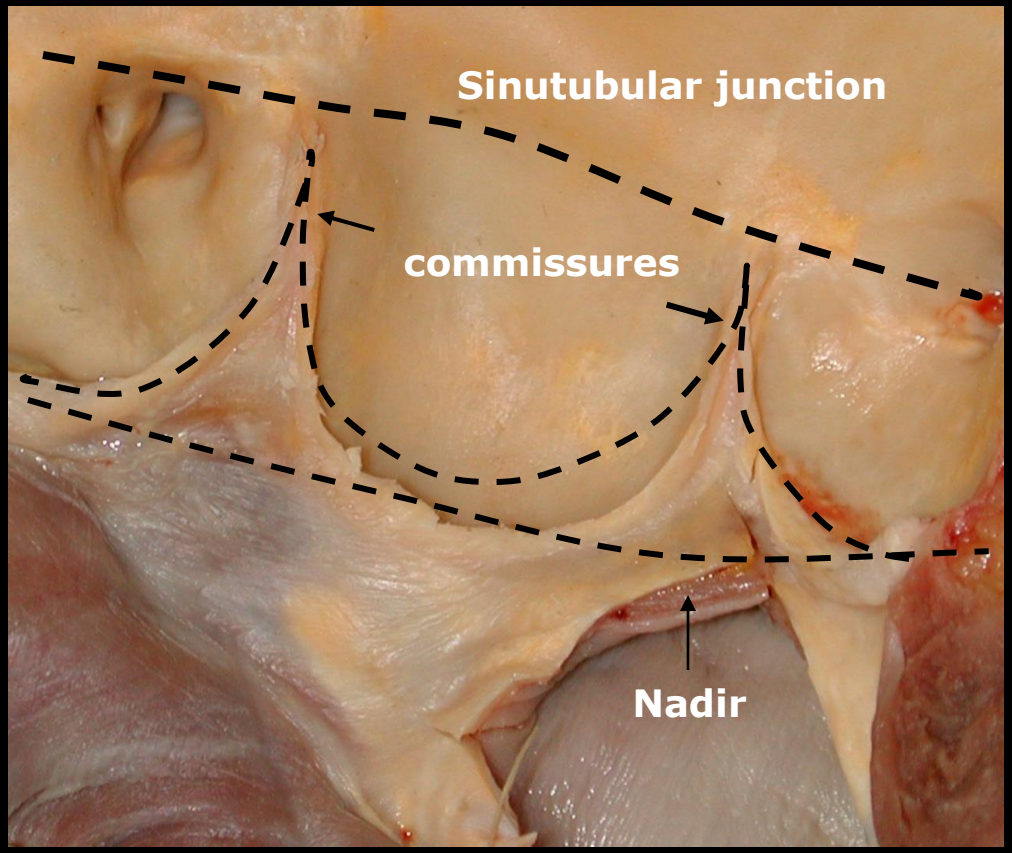
What we measure by 2D echocardiography?



Aortic Annulus ?



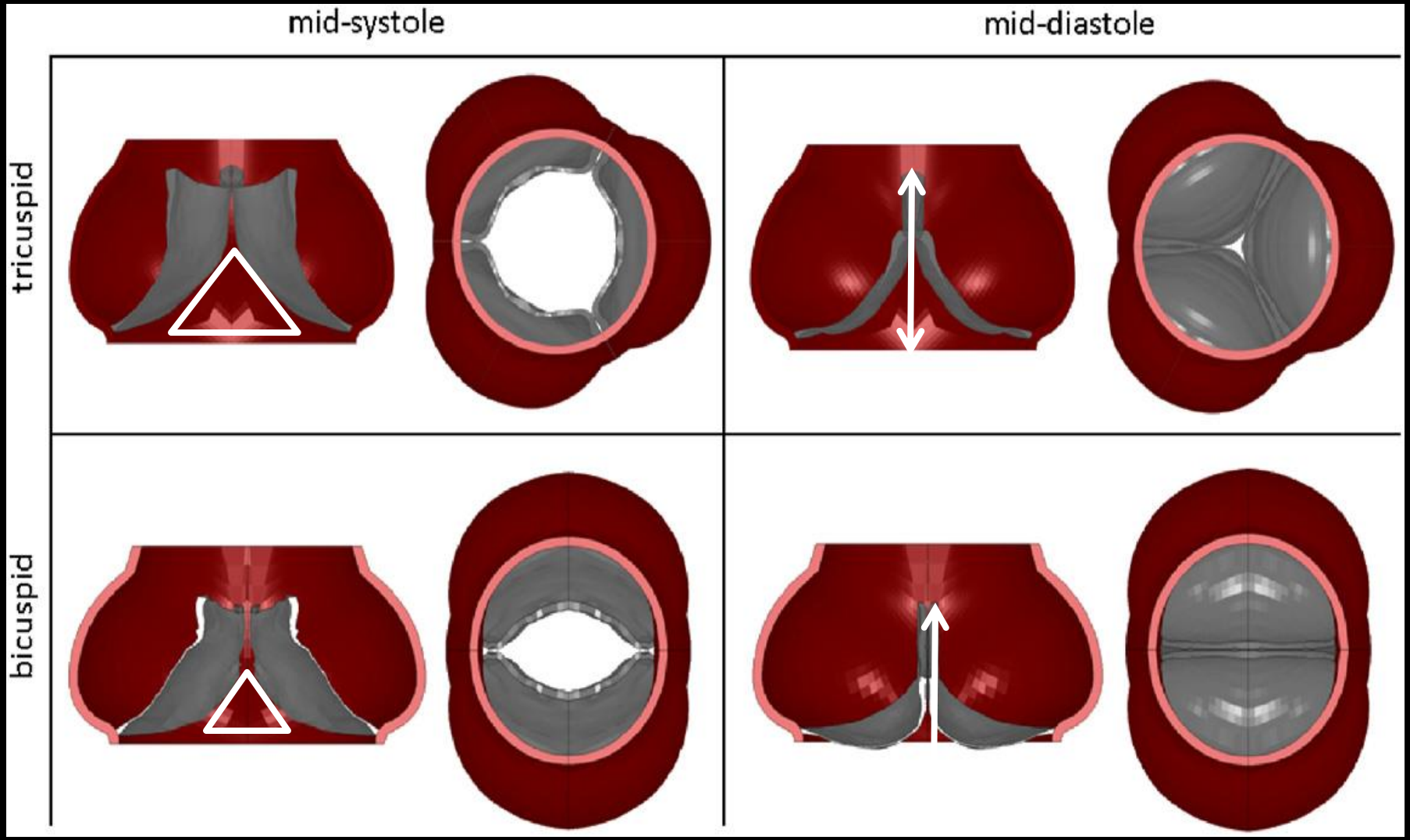
Functional aortic anulus (FAA)



FAA

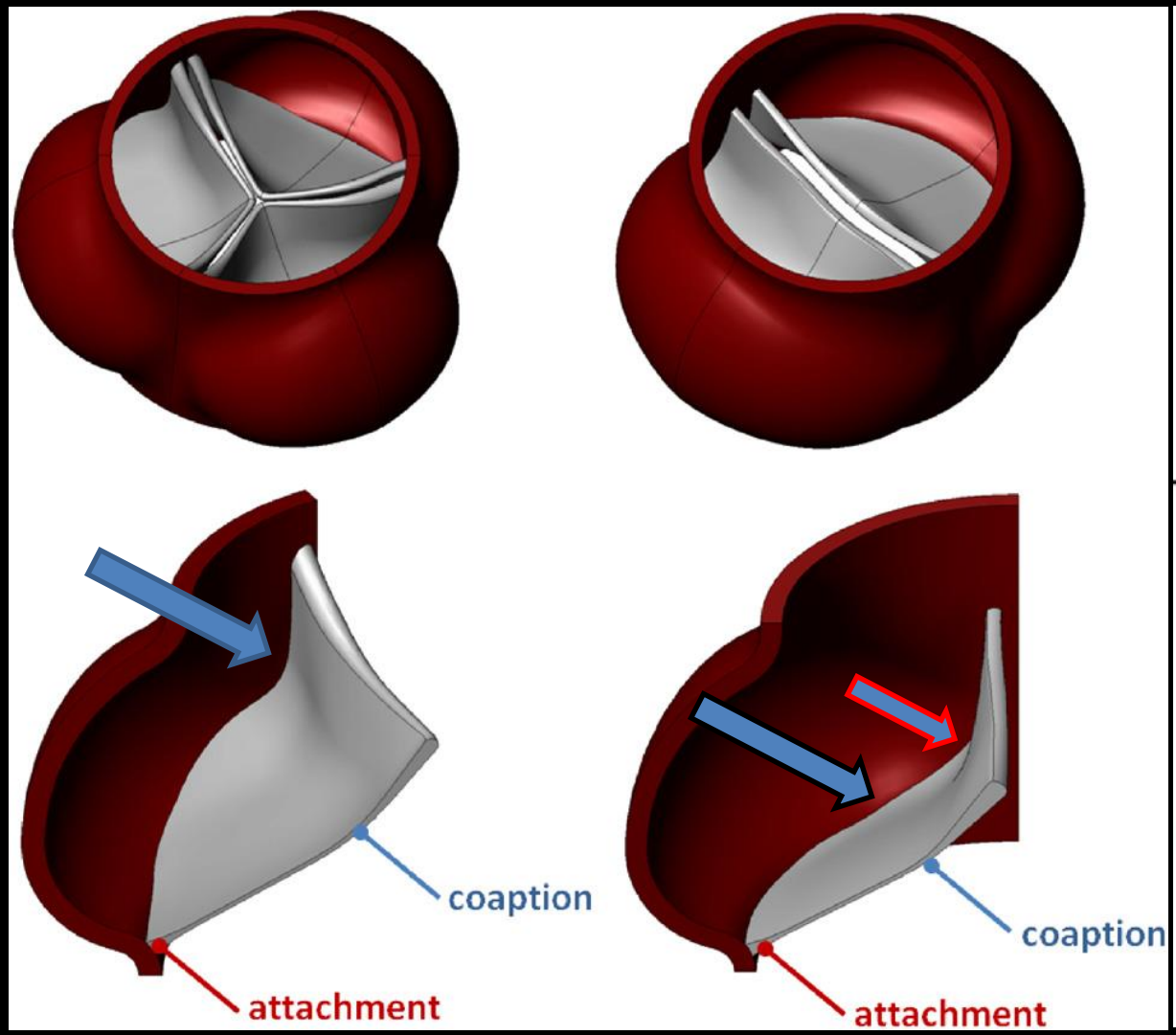
Nadir of the aortic valve
+
sinotubular junction

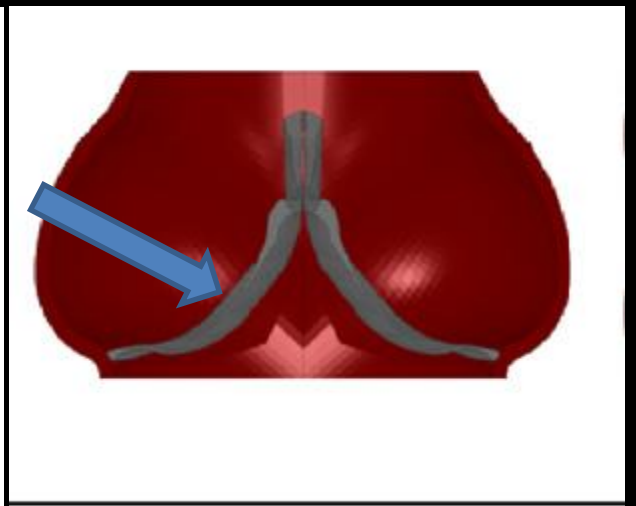
The interleaflets triangle and the coaptation are higher in Tricuspid compared to Bicuspid

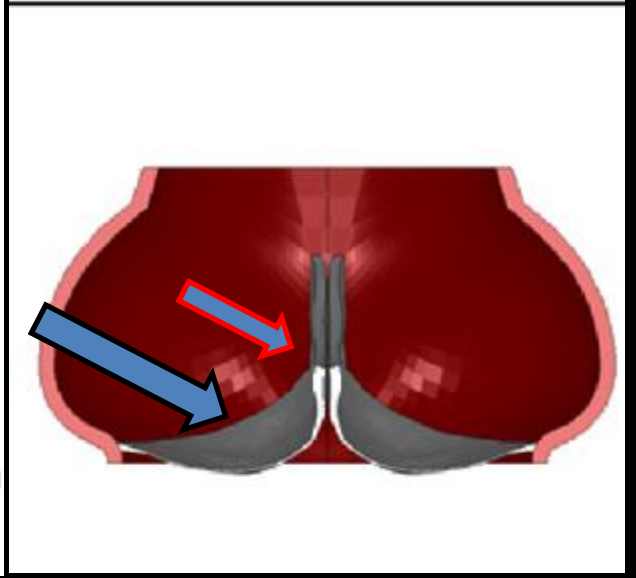


Subcommissural plasty

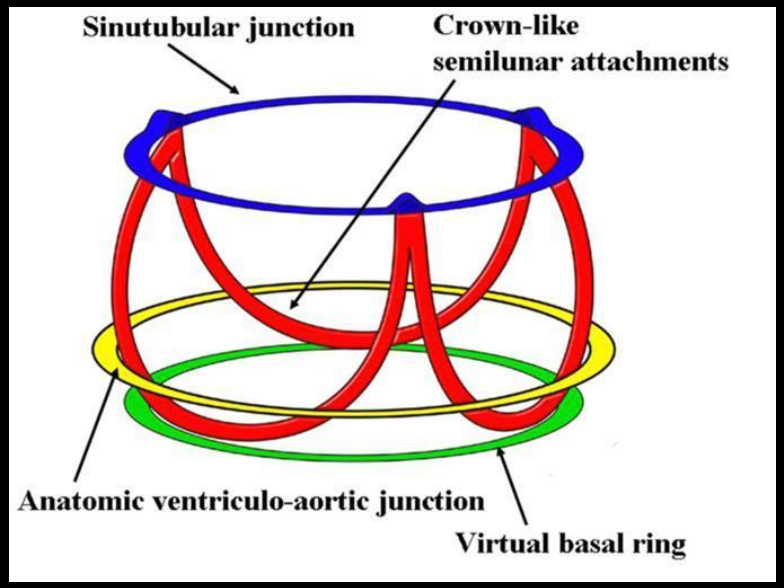
(Risk of valve stenosis)



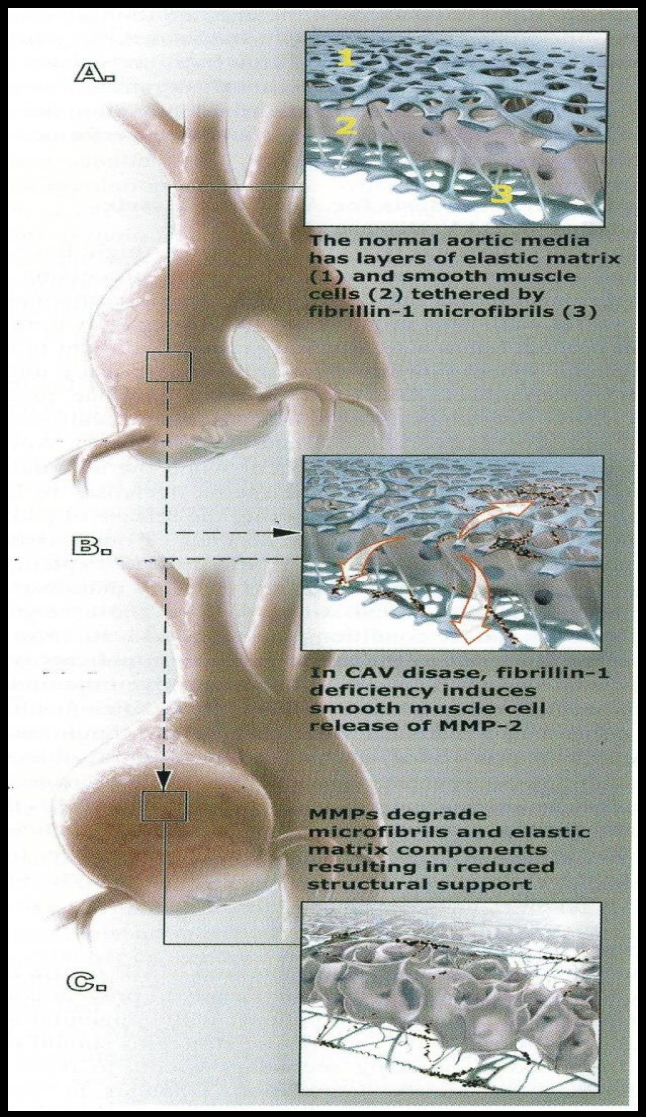




Functional Aortic Anulus (The STJ)



The STJ (blue circle) is often dilated (ascending aorta or root dilation) need replacement



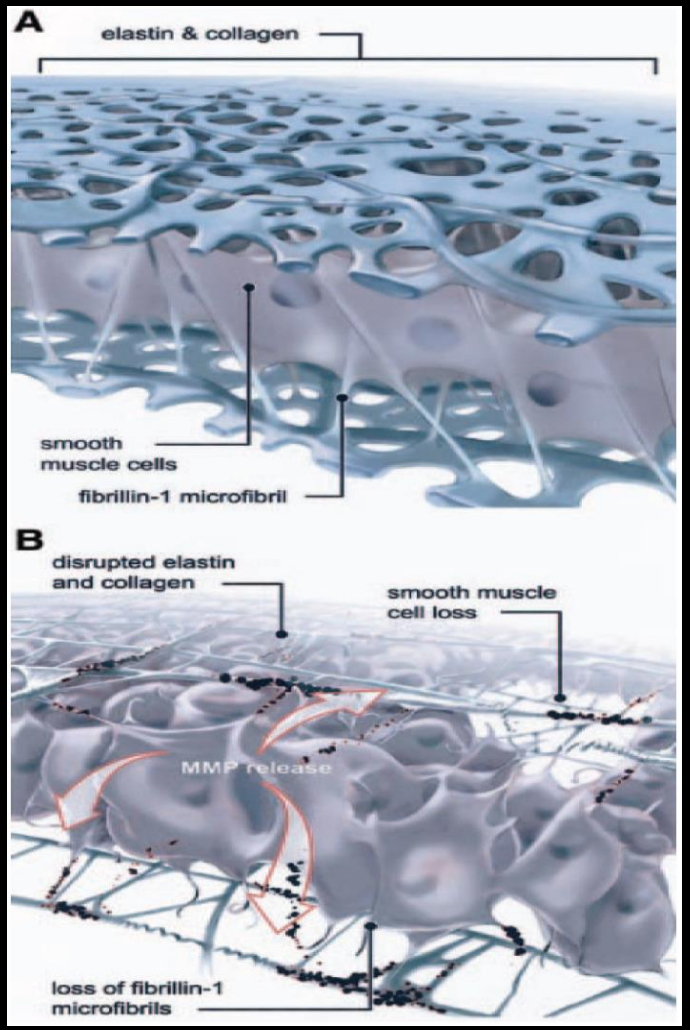
Bicuspid Aortic Valves Are Associated With Aortic Dilatation Out of Proportion to Coexistent Valvular Lesions

Martin G. Keane, MD; Susan E. Wiegers, MD; Ted Plappert, RDCS; Alberto Pochettino, MD; Joseph E. Bavaria, MD; Martin G. St. John Sutton, MBBS, FRCP

Conclusions—Aortic dimensions are larger in BAV patients than in control patients with comparable degrees of tricuspid aortic valve disease. Although more severe degrees of aortic regurgitation are associated with aortic dilatation in BAV patients, intrinsic pathology appears to be responsible for aortic enlargement beyond that predicted by hemodynamic factors. (*Circulation*. 2000;102[suppl III]:III-35-III-39.)

Ascending Aortic Dilatation Associated With Bicuspid Aortic Valve: Pathophysiology, Molecular Biology, and Clinical Implications

Thomas M. Tadros, Michael D. Klein and Oz M. Shapira



- In a normal aorta with TAV (A), fibrillin-1 microfibrils tether VSMCs to adjacent elastin and collagen matrix components.

- In patients with BAV (B), deficiency of fibrillin-1 leads to VSMC detachment, MMP release, matrix disruption, and apoptosis of VSMCs, resulting in loss of structural support and elasticity

Circulation 2009;119;880-890

New Finding ?

- in patient with BAV undergoing surgery, diameter of the AA does not represent a parameter for the benignity / extent resection.

- **In BAV repair, ascending aortic and/or root replacement is a fundamental step of valve repair (stabilize the FAA) and may improves long term results.**

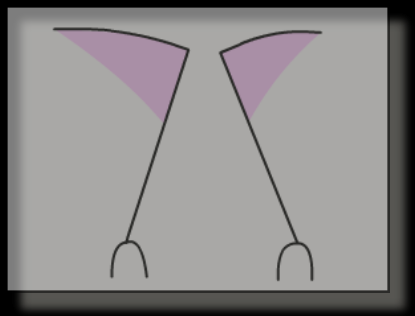
Fattouch K, et al. XI Aortic Symposium, New York 2010

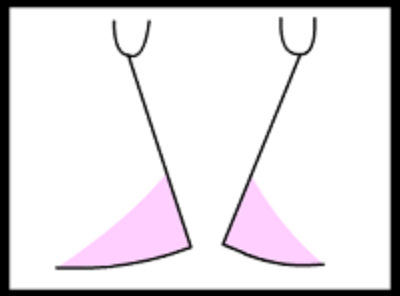
Lesson from mitral valve
Functional classification of AV regurgitation

mitral **Aortic**

Type I:

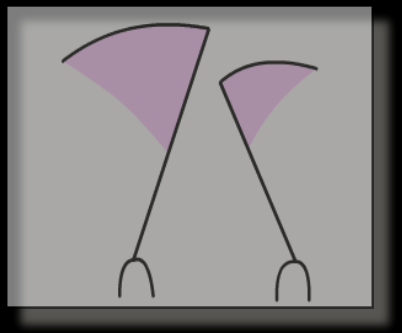
Normal leaflet motion

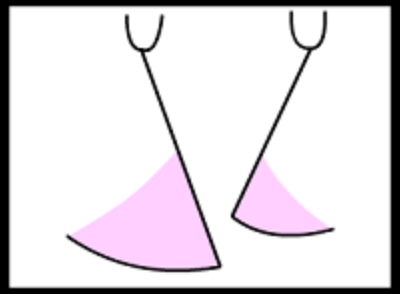




Type II:

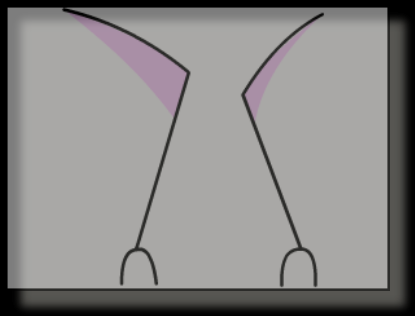
Excessive leaflets motion

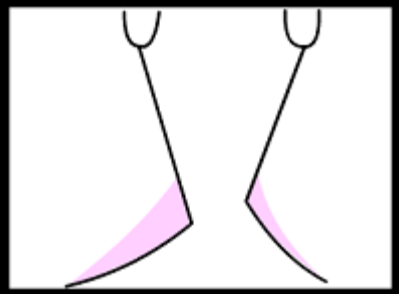




Type III:

Restrictive leaflets motion

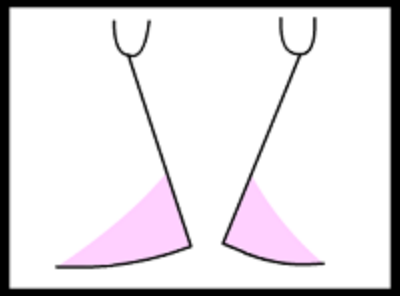




Lesson from mitral valve
Functional classification of AV regurgitation

Type I:

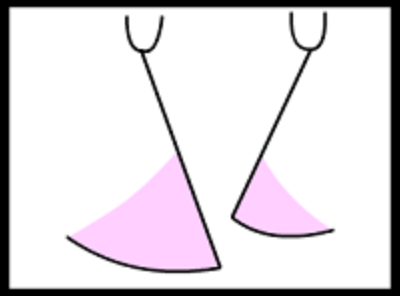
Normal leaflet motion



- **Ia – STJ dilatation**
- **Ib – Valsalva sinuses dilatation**
- **Ic – FAA dilatation**
- **Id – Perforazione**
- **Ie – Hypertrophy of noduli Aranzio**

Type II:

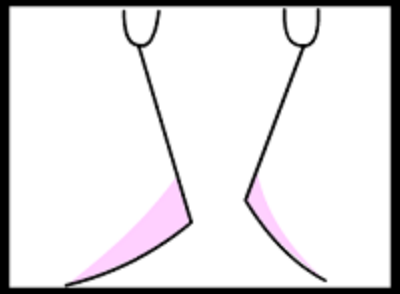
Excessive leaflets motion



- **Prolapse**
- **Dissection**

Type III:

Restrictive leaflets motion



- **Calcification**
- **Cusps fusion**

Bicuspid Valve Repair

Leaflets repair:

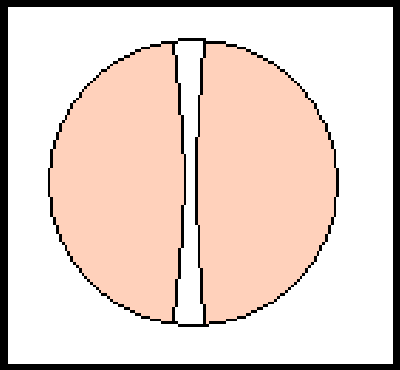
Prolapse

1. Free edge reinforcement with GoreTex
2. Plication
3. Triangular resection

Restrictive

1. Raphe resection or shaving and re-suturing
2. Pericardial patch extension

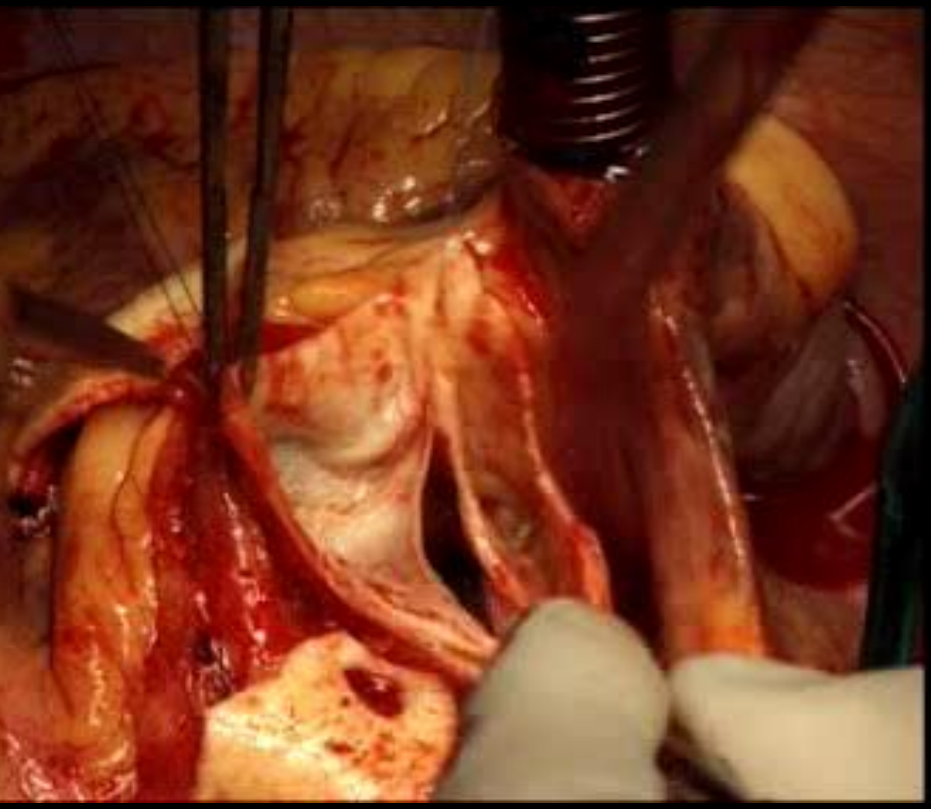
Phenotype of Bicuspid valve

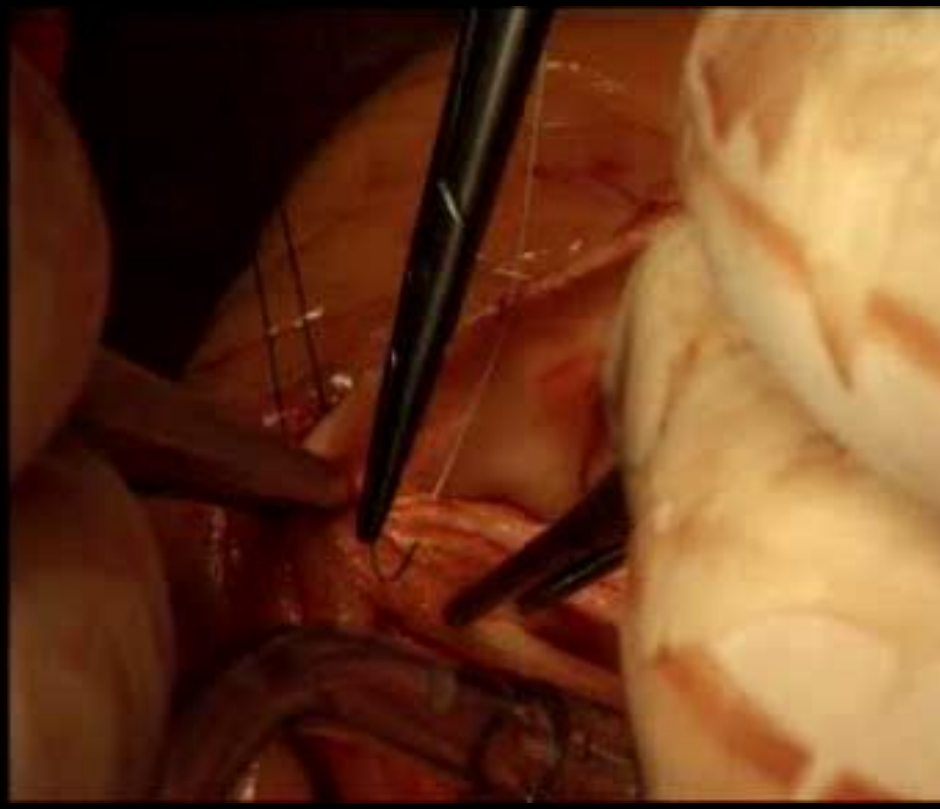


Type 0: True bicuspid valve.
Two leaflets usually of the same length.
No raphe
2 commissures.
Two Valsalva sinuses.

Incompetence mechanism: prolapse of one cusp causing an eccentric jet

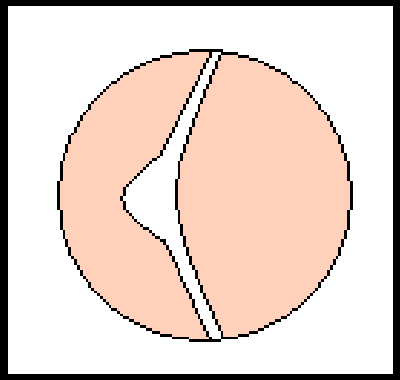
Bicuspid valve – Type 0





Morphology: R-L fusion
Mechanism: Root dilation + Prolapse
Surgery: David + free edge reinforcement with Gore-Tex

Morphology: R-NC fusion
Mechanism: Leaflets prolapse
Surgery: Free edges reinforcement with Gore-Tex



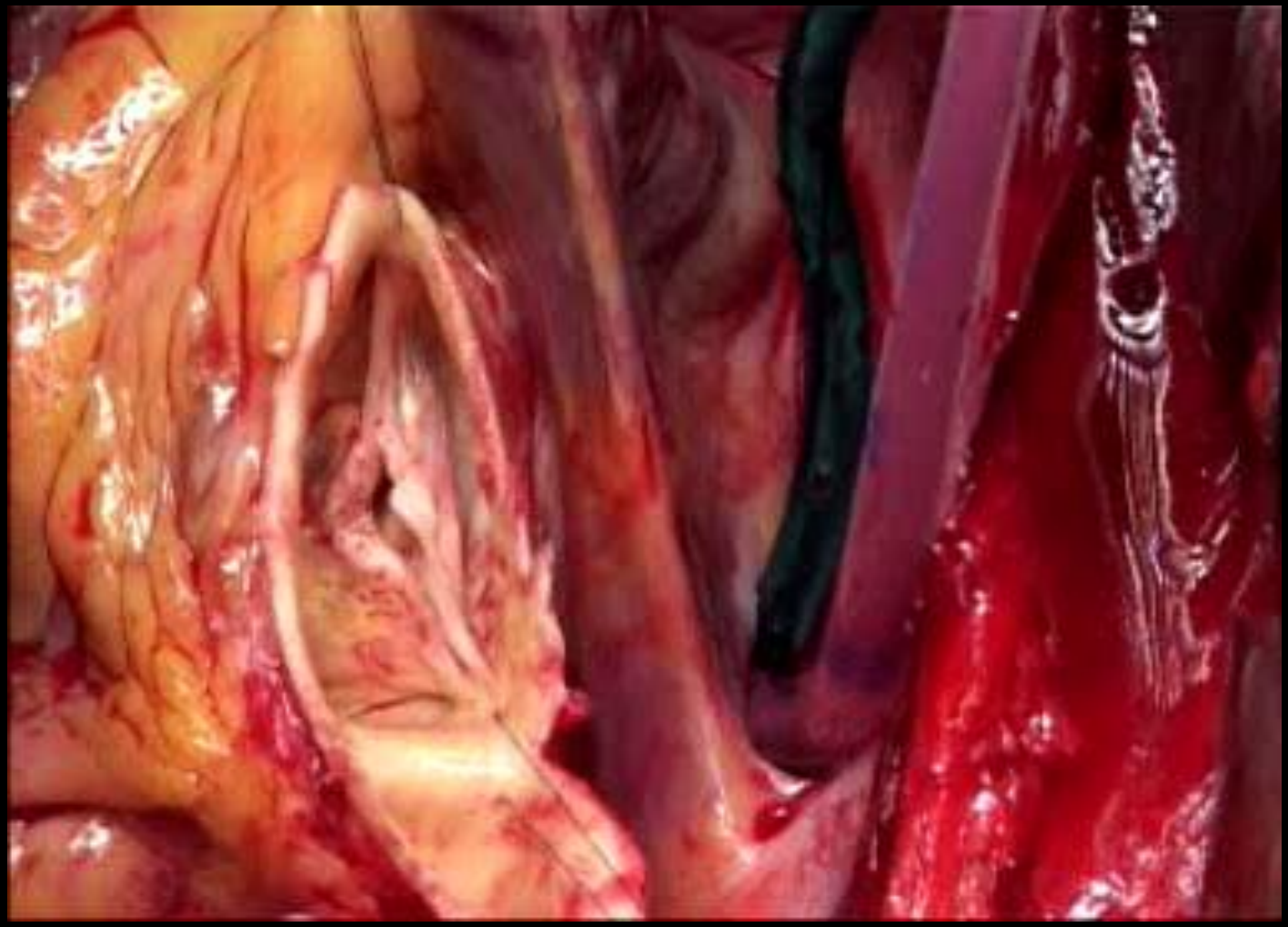
Tipo 1: Pseudo-bicuspid valve

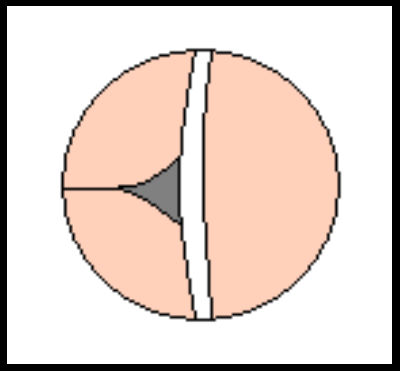
- Two small leaflets (fused) with a commissure between them
- 3 leaflets, 3 commissures .
- 3 sinuses (tricuspid)
- bicuspid valve with 2 sinuses + 2 leaflets and a cleft)

Incompetence mechanism: free edges fibrotic degeneration of the 2 small cusps creating central or eccentric jet.

Bicuspid valve – Type 1

Triangular resection + direct suturing + David



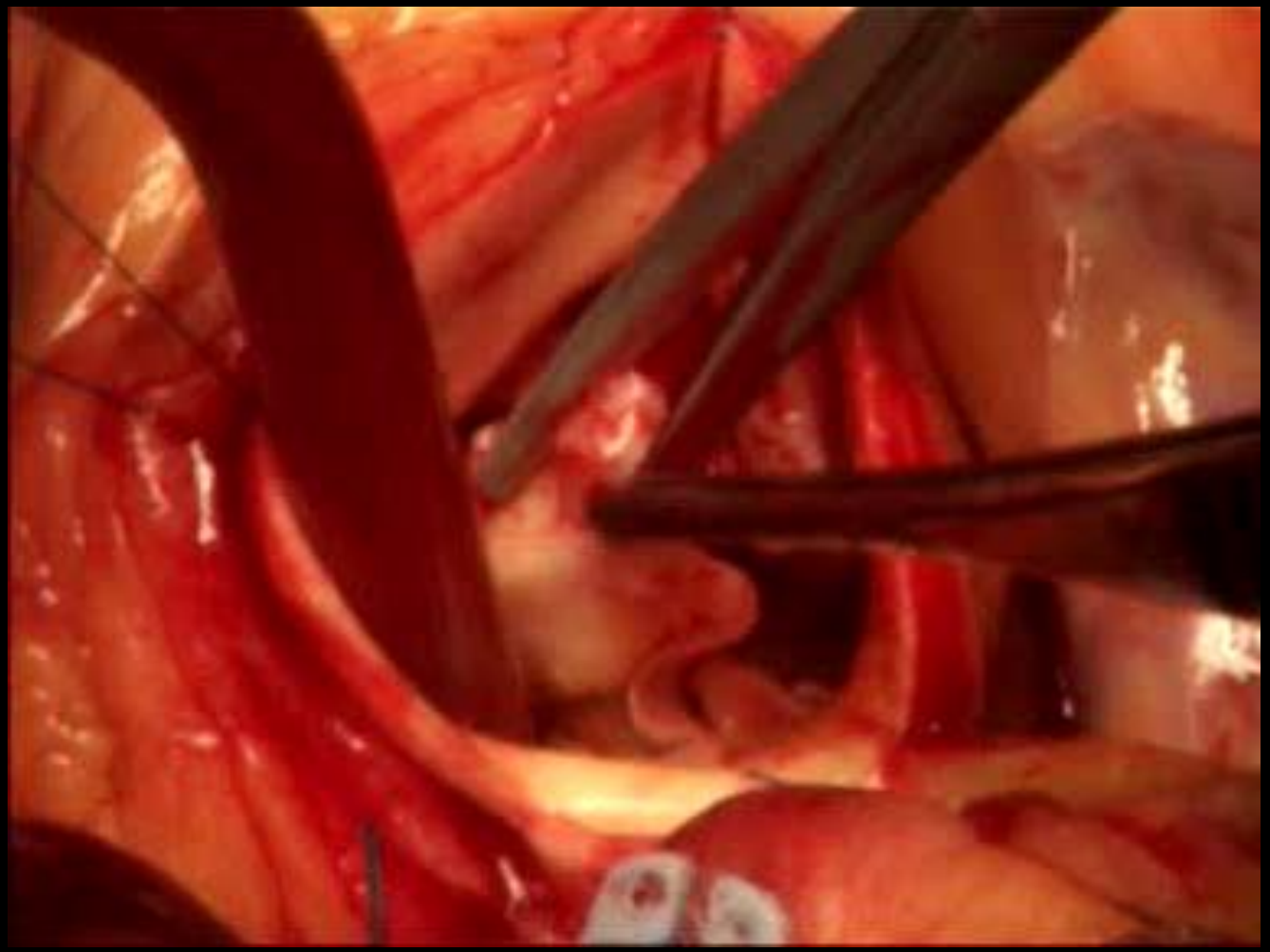


Tipo 2: Fibrotic or calcified raphe , usually hampering the normal leaflet motion or retracting the free edge towards the anulus (2 or 3 valsalva sinuses)

Incompetence mechanism: pseudo prolapse of the other cusp causing an eccentric jet or retraction with restrictive motion.
Incomplete closure with central jet (2 raphe)

Bicuspid valve - Type 2

Resection of clcified raphe + pericardial patch reconstruction



Intermediate-term durability of bicuspid aortic valve repair for prolapsing leaflet[1]

Filip P. Casselman[a], A. Marc Gillinov[a], Rami Akhrass[a], Vigneshwar Kasirajan[a], Eugene H. Blackstone[a,b], Delos M. Cosgrove[a,*]

[a]*Department of Thoracic and Cardiovascular Surgery, The Cleveland Clinic Foundation, Cleveland, OH, USA*
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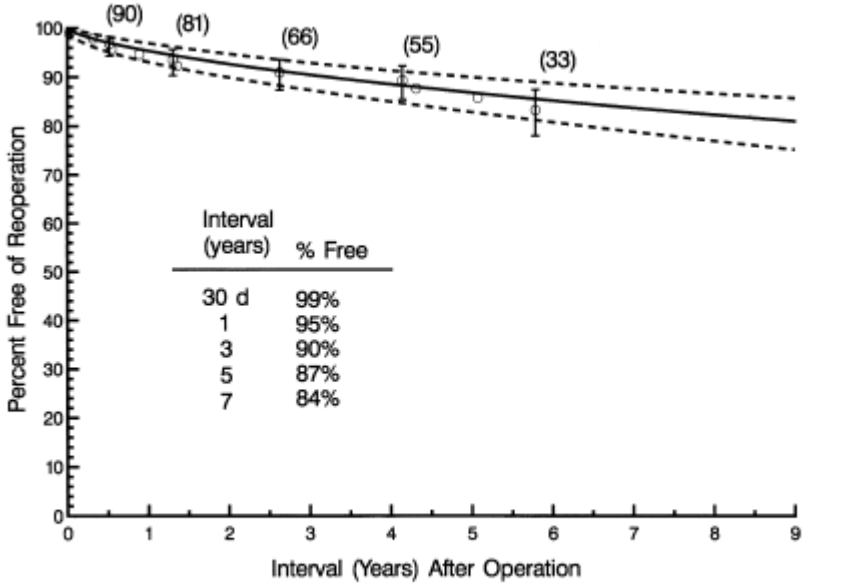

Fig. 1. Freedom from aortic valve reoperation during follow-up.

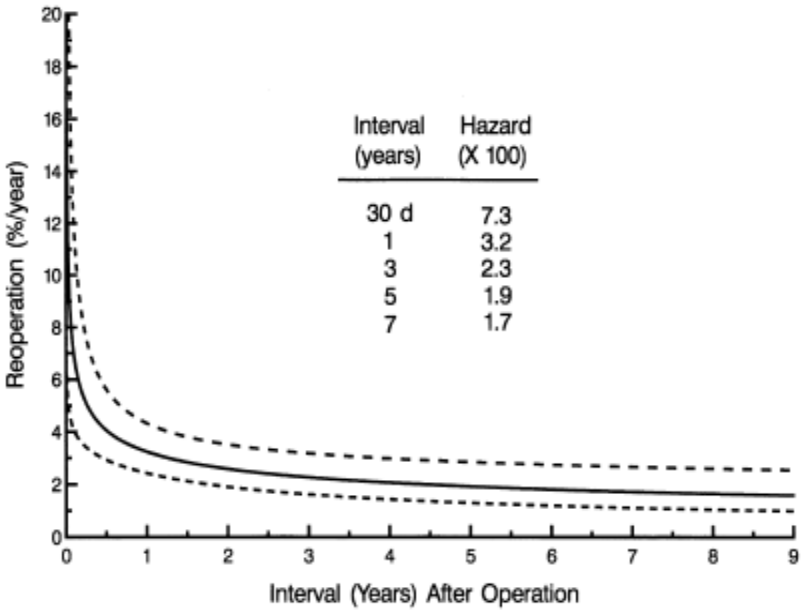

Fig. 2. Instantaneous risk for aortic valve reoperation during follow-up.

European Journal of Cardio-thoracic Surgery 15 (1999) 302–308

Aortic Valve Repair Using a Differentiated Surgical Strategy

Frank Langer, MD; Diana Aicher, MD; Anke Kissinger, Olaf Wendler, MD; Henning Lausberg, MD; Roland Fries, MD; Hans-Joachim Schäfers, MD

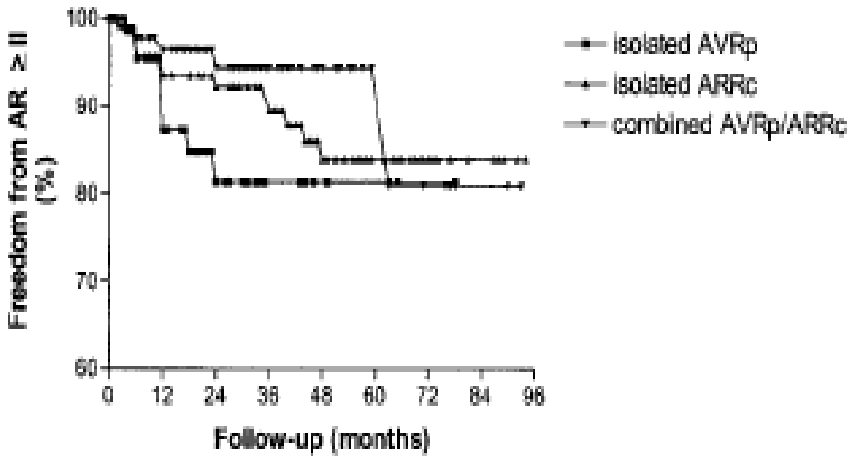

Figure 7. Freedom from AR grade ≥II (AVRp indicates aortic valve repair; ARRc, aortic root reconstruction).

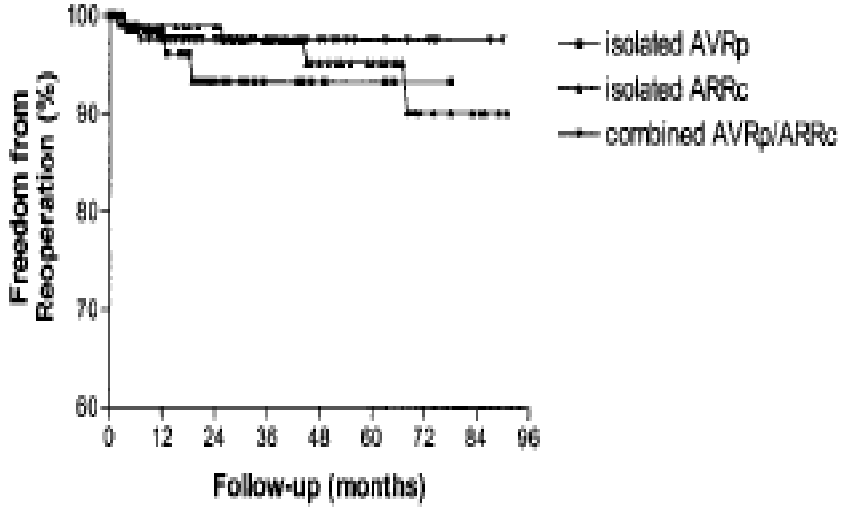

Figure 8. Freedom from reoperation.

Actuarial freedom from AR > II after 5 years was 88% **(isolated AVR 81%, isolated root reconstruction 85%, combination 94%)**

(*Circulation*. 2004;110[suppl II]:II-67–II-73.)

Repair of Bicuspid Aortic Valves in Patients With Aortic Regurgitation

Gébrine El Khoury, MD; Jean-Louis Vanoverschelde, MD, PhD; David Glineur, MD; Frédéric Pierard, MD; Robert R. Verhelst, MD; Jean Rubay, MD, PhD; Jean-Christophe Funken, MD; Christine Watremez, MD; Parla Astarci, MD; Valérie Lacroix, MD; Alain Poncelet, MD; Philippe Noirhomme, MD

TABLE 4. Comparison Between the Patients With or Without a Preoperative Severe AR in Terms of Reoperation and Long-Term Recurrence of AR Equal to Grade 2

	AR<grade 2	AR>grade 3
Bicuspid valve repair + Aneurysm of the aortic root	47% of the subgroup Reoperation: 1 patient at day 8 (ROSS) 1 patient at 98 months (AO stenosis)	53% of the subgroup Reoperation: 1 patient at day 7 (disruption suture) Follow-up echo: 3 patients with AR=2
Isolated bicuspid valve repair		100% of the subgroup Reoperation: 1 patient at day 11 (disruption suture) 1 patient at 23 months (perforation of the patch) Follow-up echo: 1 patient with AR=2

Conclusion—Our data indicate that regurgitant bicuspid aortic valves, whether alone or in association with a proximal aortic dilatation, can be repaired successfully provided that both the valve and the aortic root problems are treated simultaneously. (*Circulation*. 2006;114[suppl I]:I-610–I-616.)

Preservation of the Bicuspid Aortic Valve

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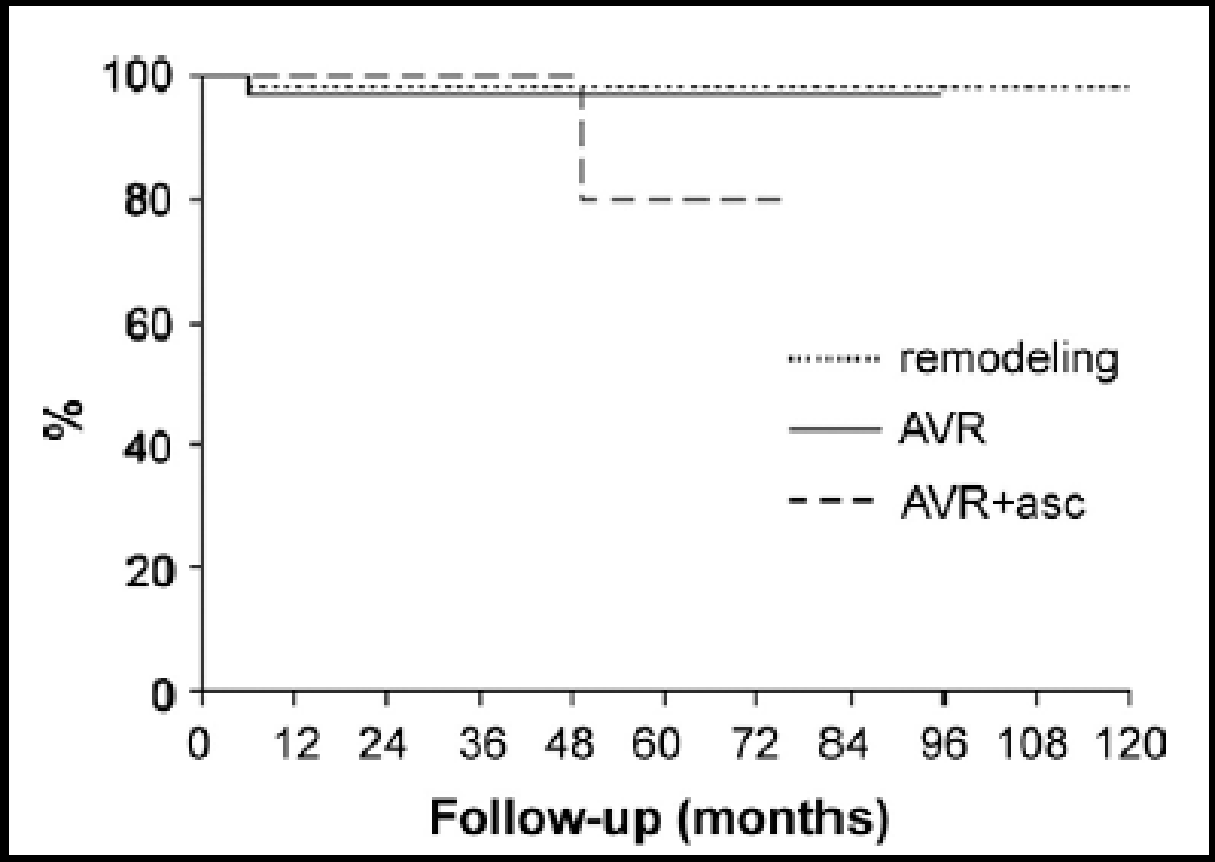


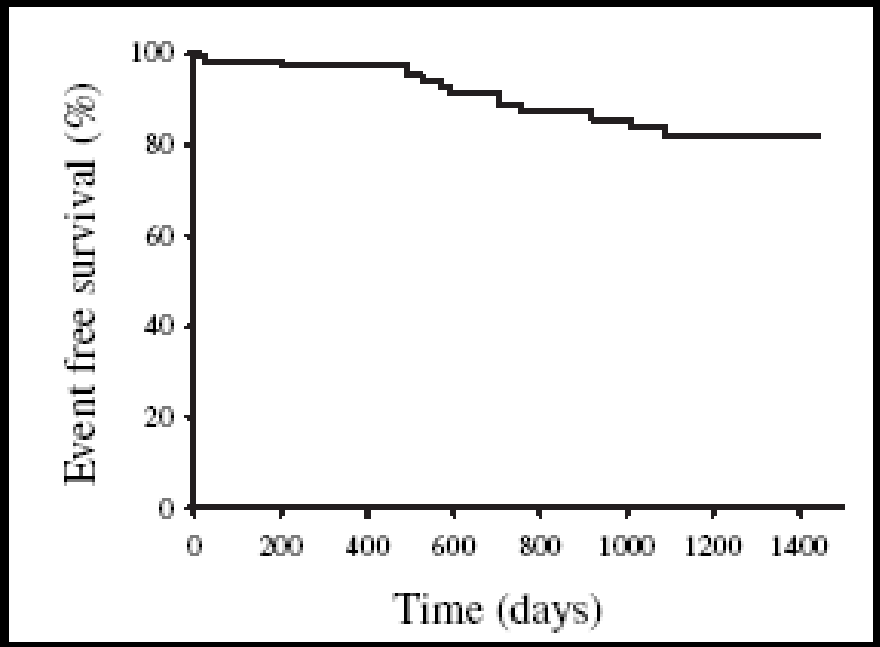
Freedom from AV replacement.

(Ann Thorac Surg 2007;83:S740–5)

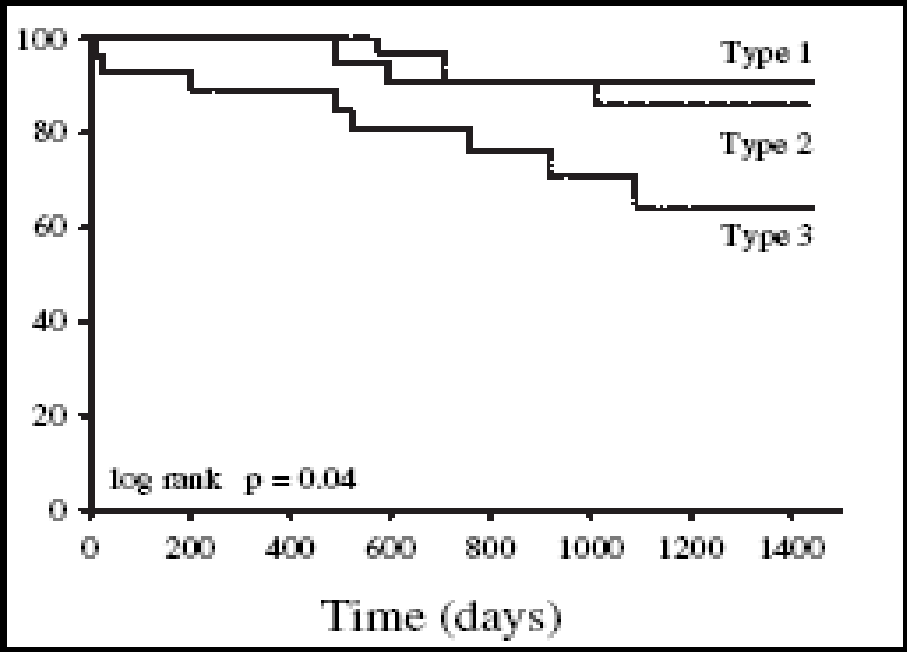
Functional Anatomy of Aortic Regurgitation

Accuracy, Prediction of Surgical Repairability, and Outcome Implications of Transesophageal Echocardiography

Jean-Benoît le Polain de Waroux, MD*; Anne-Catherine Pouleur, MD*; Céline Goffinet, MD; David Vancraeynest, MD; Michel Van Dyck, MD; Annie Robert, PhD; Bernhard L. Gerber, MD, PhD; Agnès Pasquet, MD, PhD; Gébrine El Khoury, MD; Jean-Louis J. Vanoverschelde, MD, PhD



Event-free survival.



Event- free reoperation.

(*Circulation*. 2007;116[suppl I]:I-264–I-269.)

Aortic valve repair with autologous pericardial patch☆

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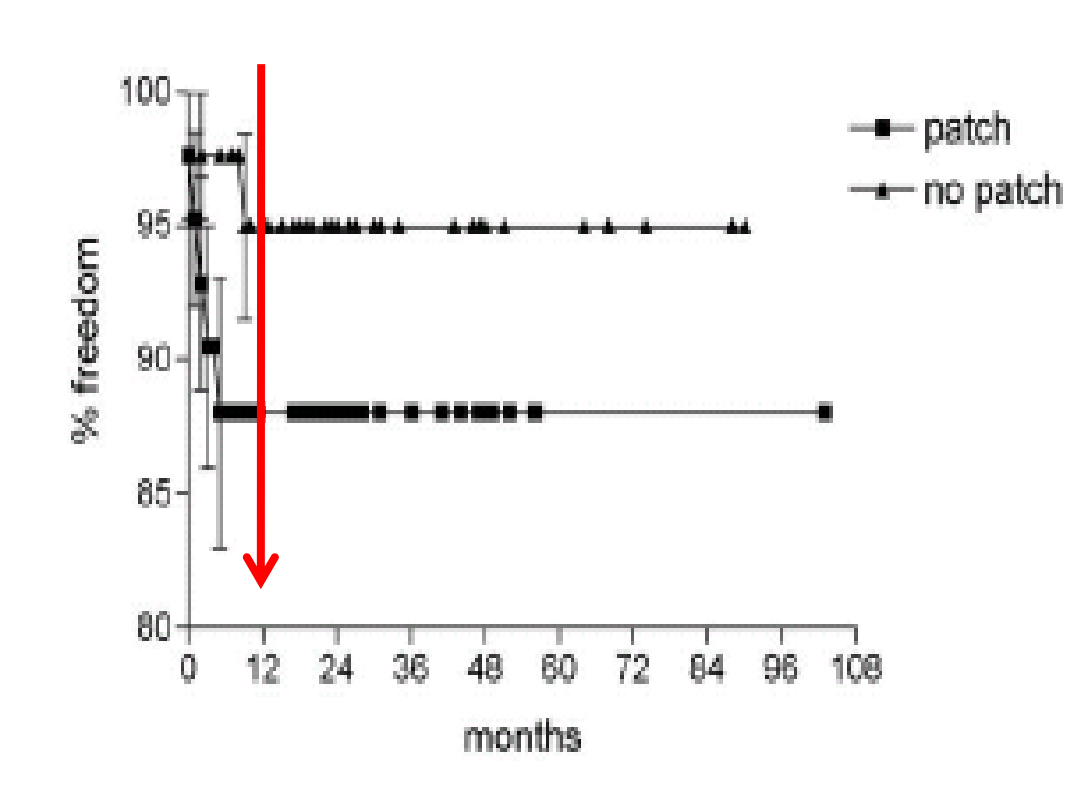

Actuarial freedom from AV reoperation

European Journal of Cardio-thoracic Surgery 30 (2006) 244–249

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Outcomes of aortic valve repair according to valve morphology and surgical techniques

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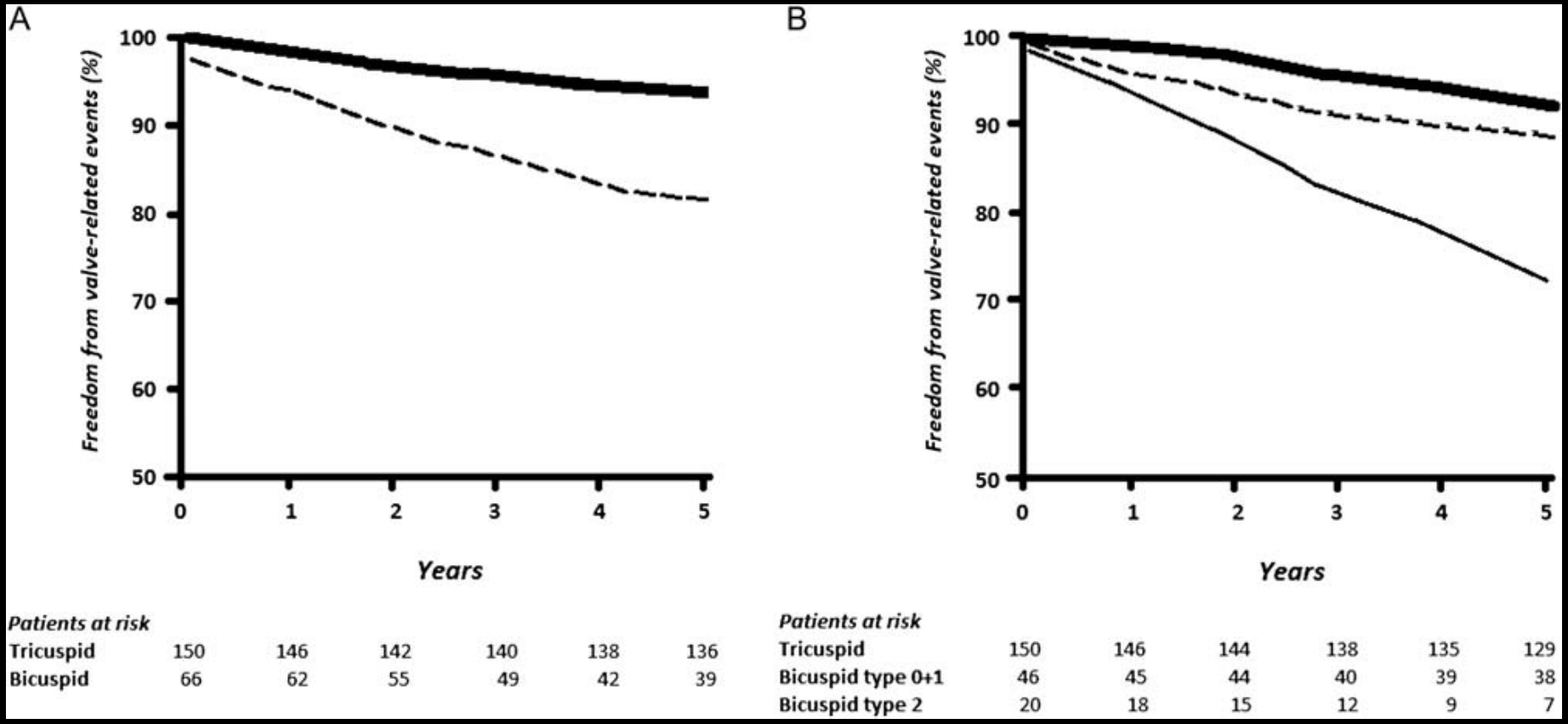

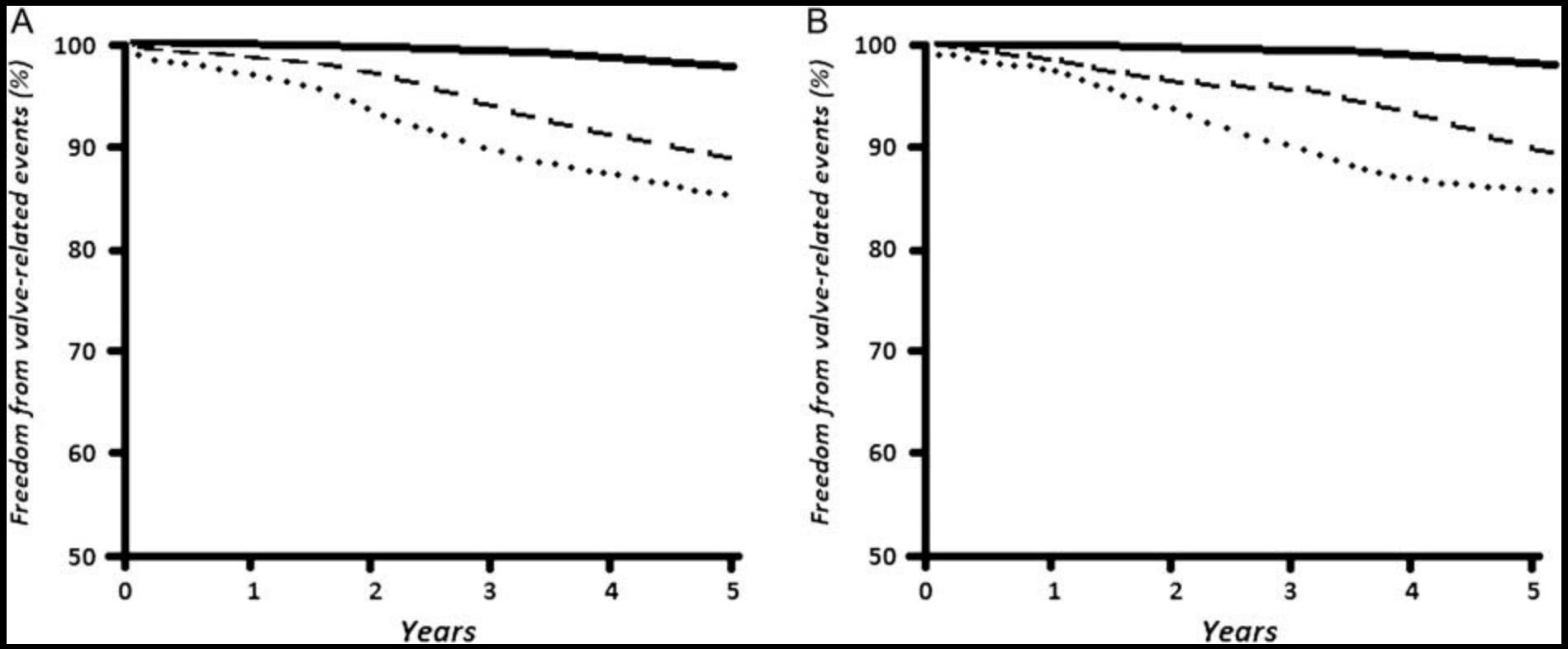

(A) Tricuspid. (B) Bicuspid. Freedom from aortic valve-related events for patients who underwent aortic valve-sparing (solid line), ascending aorta replacement (dashed line) and isolated aortic valve repair (dotted line).

Table 3: Predictors for valve-related events in all patients by Cox regression analysis

Variables	*P* value	HR	95% CI
Bicuspid type 2	0.0003	10	6.6–92
Type III dysfunction	0.001	7.0	1.9–50
Free-edge reinforcement	0.01	5	1.7–15
Isolated AVR	0.01	8	2.1–35

HR: Hazard ratio; CI: Confidential interval; AVR: aortic valve repair.

Conclusions

1. BAV repair is associated with low mortality and morbidity.
2. Good results in phenotype 0 and 1.
3. Avoid repair (severe calcification).
4. Attention to avoid valve stenosis
5. Better results when the aortic root was replaced (repair stabilization ?).
6. Pericardial patch need more follow-up.