IV CONGRESSO NAZIONALE DI
ECOCARDIO CHIRURGIA
MILANO 10-12 MARZO 2010

# La tecnica di *Tirone David*: da una intuizione fisiopatologica la soluzione chirurgica della insufficienza aortica a valvola integra

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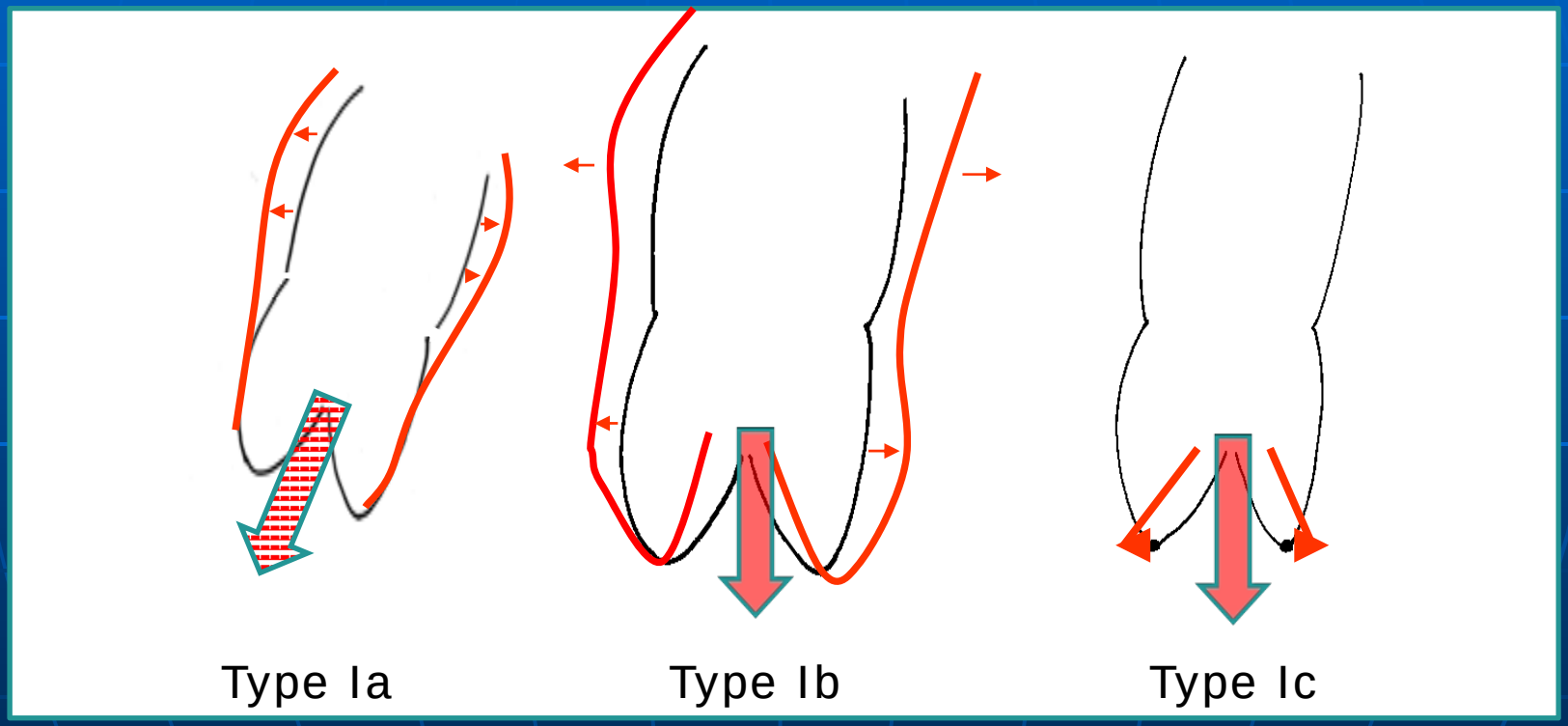
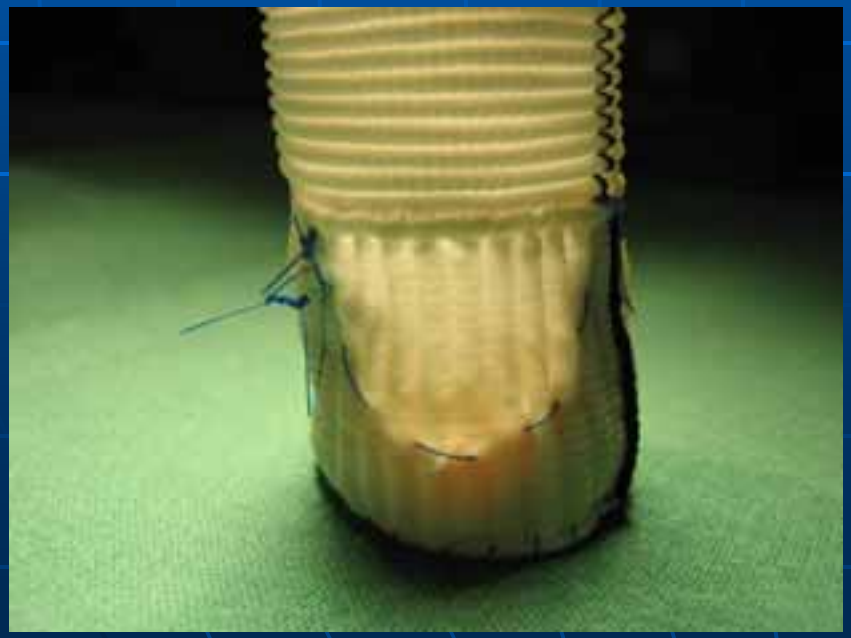
*European Hospital Roma*

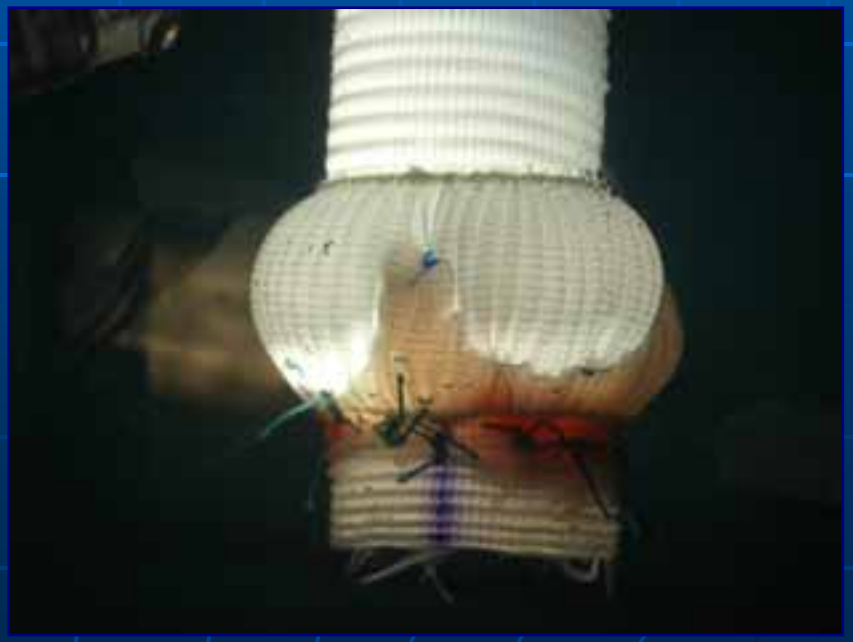
# Causes of aortic regurgitation (with normal leaflets)

- FAA pathology (dilatation)




*Often valve regurgitation derives from multilesions combined in a variety of associations*





# The paradoxes of the aortic valve

- ✓ The valve opens before the presence of forward flow
- ✓ Ejection continues even after the aortic pressure exceedes ventricular pressure
- ✓ The aortic valve already starts closing during ejection

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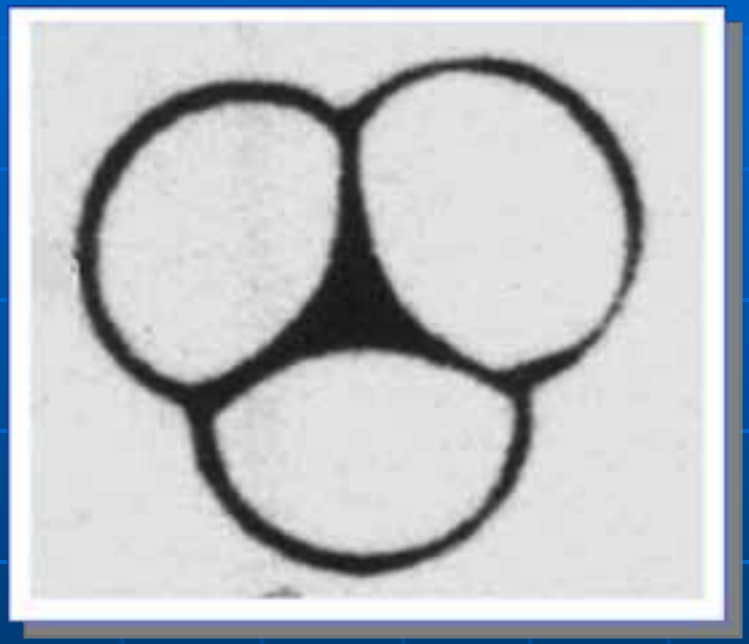
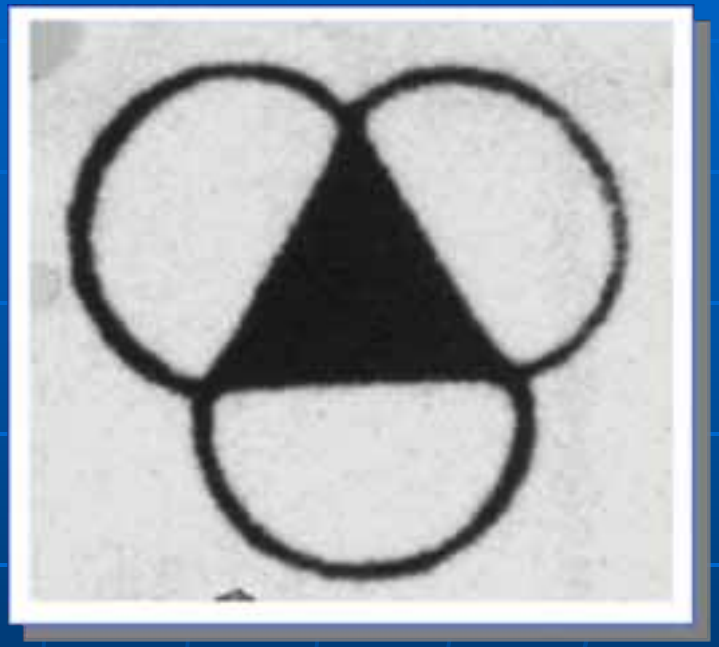
# Answer:

From stellate orifice to small triangle

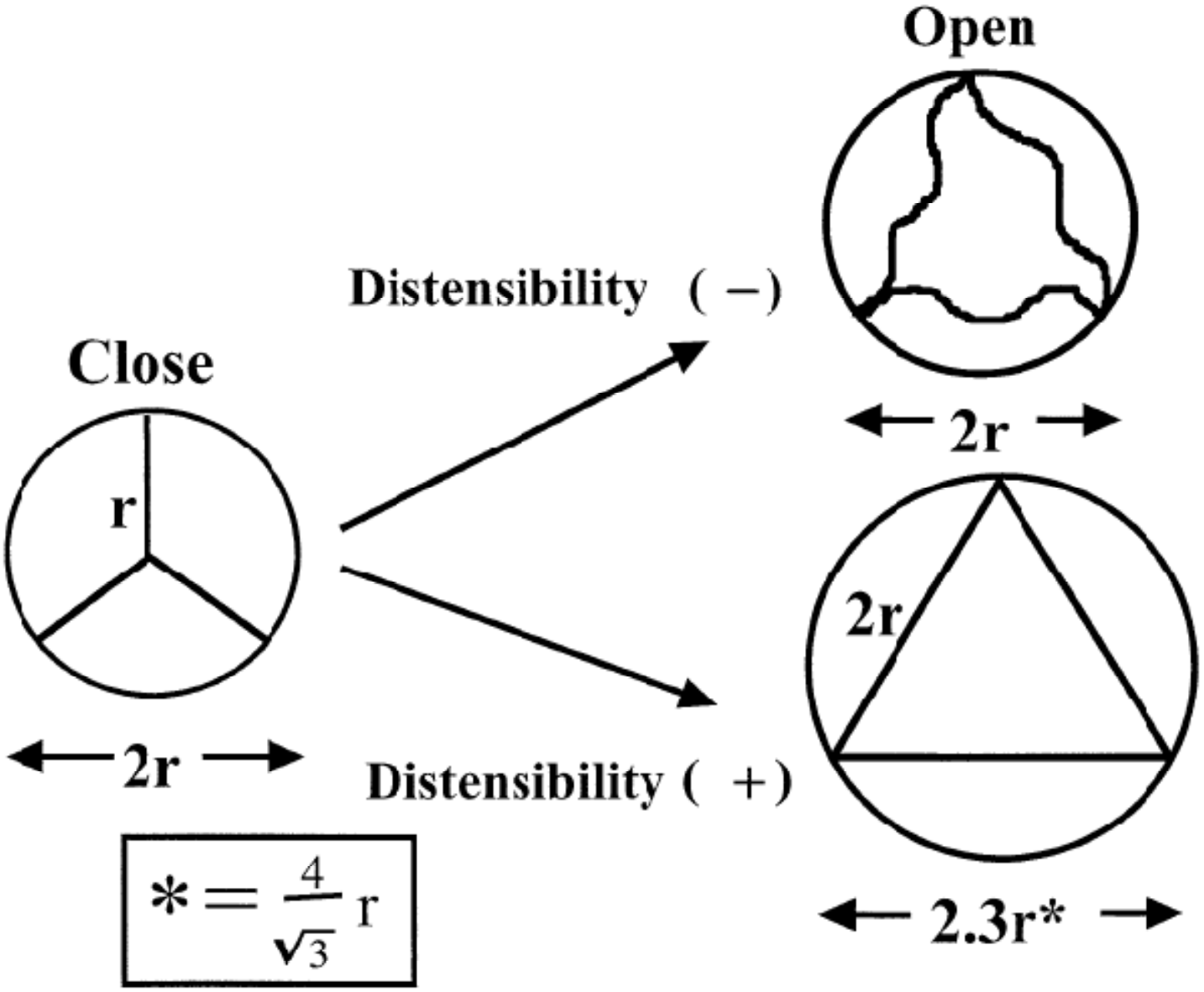
Increase in ventricular pressure through the interleaflet triangle causes an increase of diameter at the commissures before the valve opens





From small triangle to triangle

Sinuses expansion (increased 16%) to maintain the leaflet distended and flat


Open
Distensibility ( −)
Close
r
2r
2r
Distensibility ( +)
2r
2.3r*
* = 4/√3 r

# The paradoxes of the aortic valve

- ✓ The valve opens before the presence of forward flow
- ✓ Ejection continues even after the aortic pressure exceedes ventricular pressure
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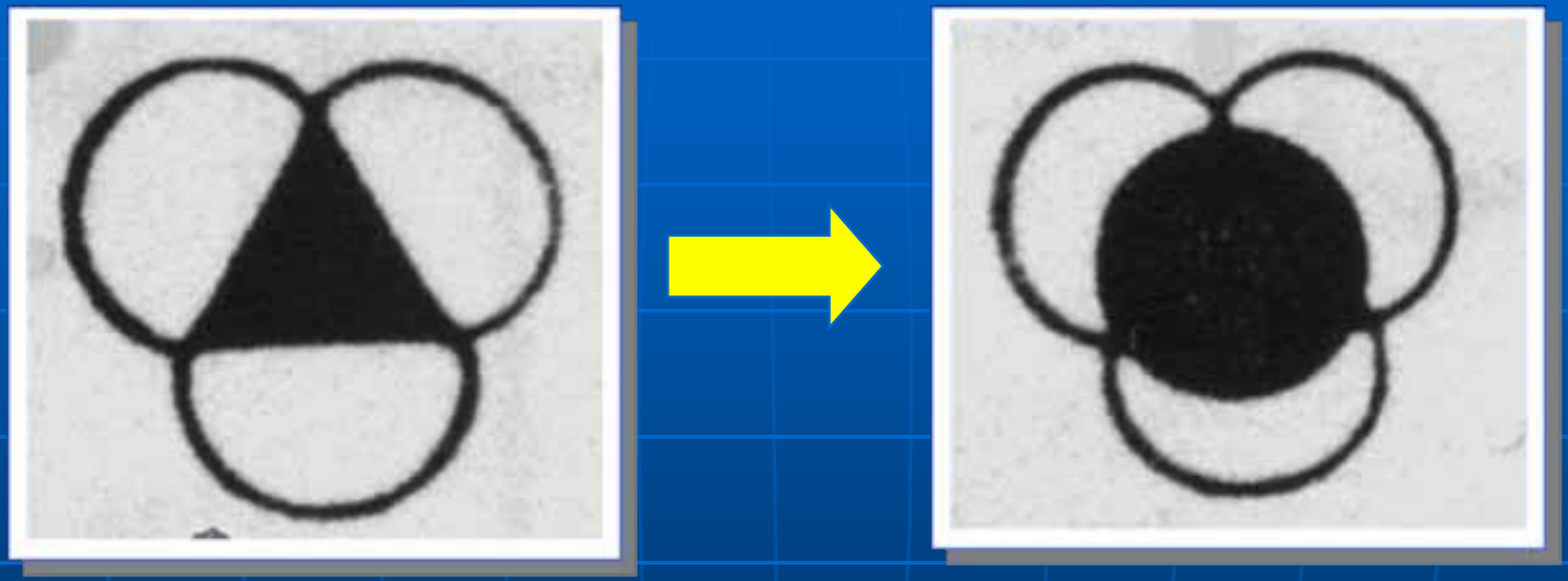
# Answer:



From triangle to circular orifice

Due to an increase in velocity the blood enter the aorta because of motion's inertia more than pressure gradient"

**"Noble phenomenon"**

# The paradoxes of the aortic valve

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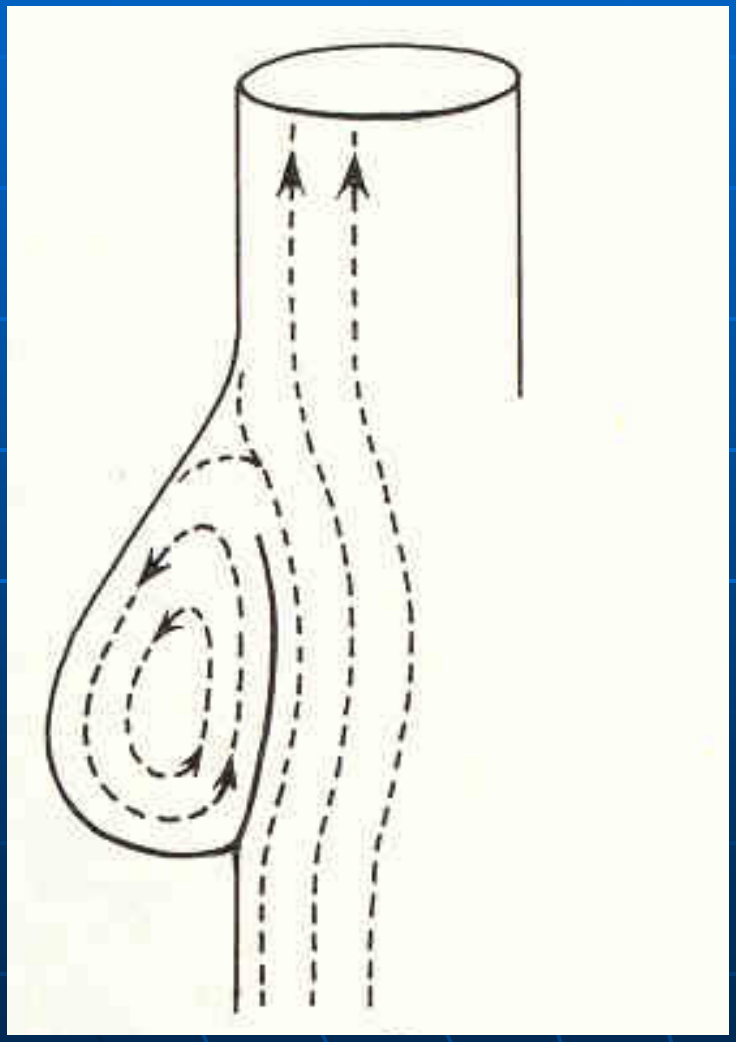
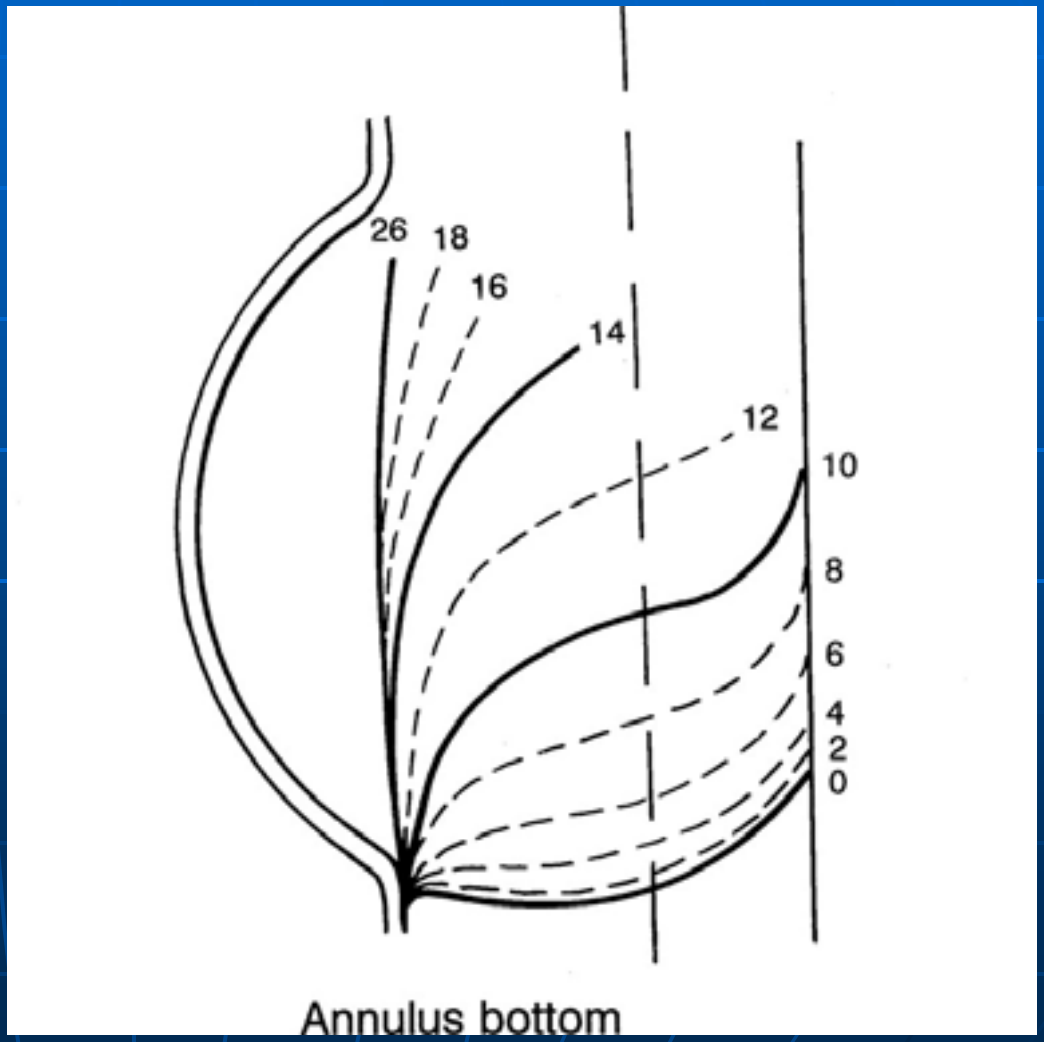
- ✓ Ejection continues even after the aortic pressure exceedes ventricular pressure
- ✓ The aortic valve already starts closing during ejection

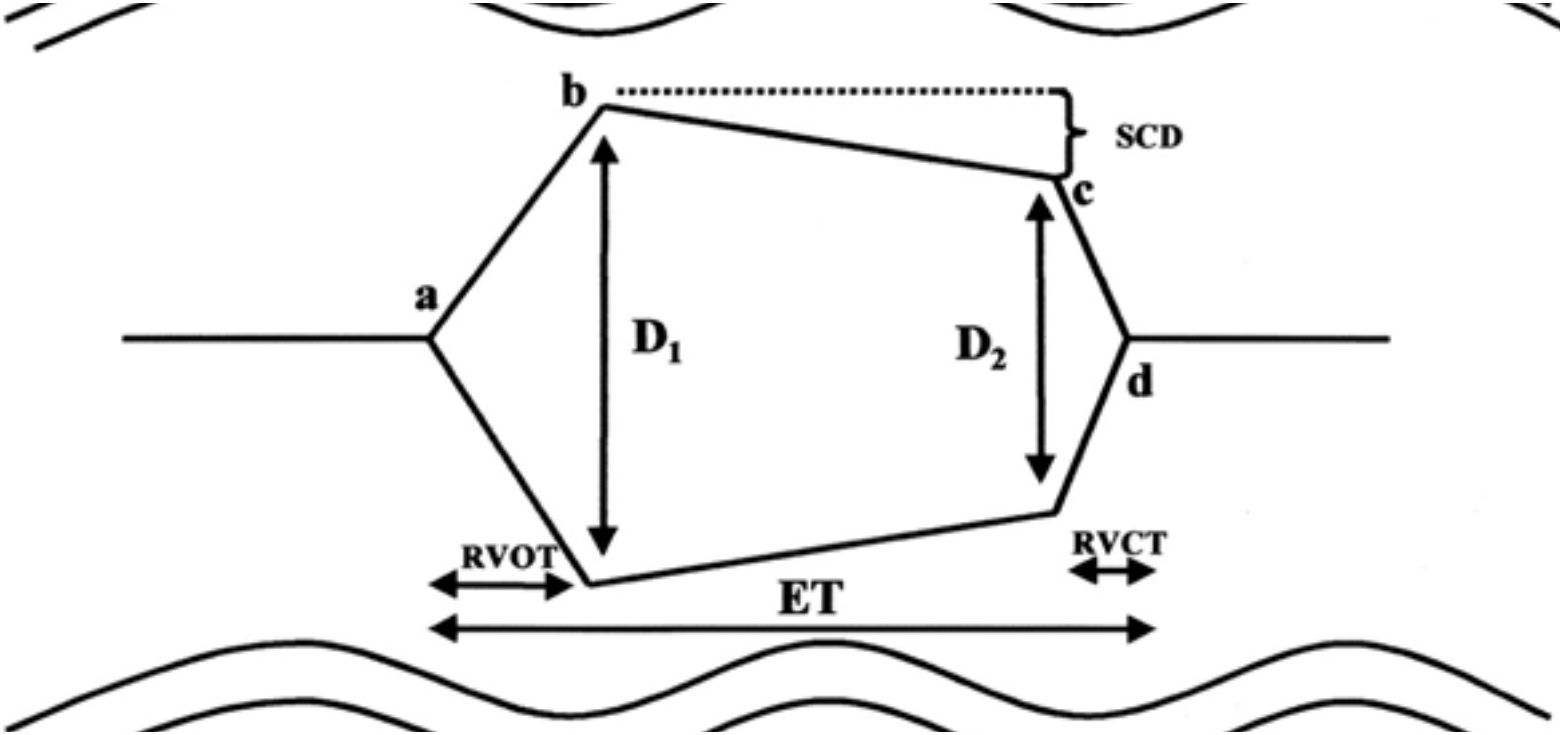
# Mechanism of leaflets closure: the role of the sinuses





# Answer:

*a-b* = rapid valve opening; *b-c* = slow systolic closure; *c-d* = rapid valve closing; *RVOT* = rapid valve opening time; *RVCT* = rapid valve closing time; *ET* = ejection time; *D1* = maximal leaflet displacement; *SCD* = slow closing displacement; *D2* = leaflet displacement before rapid valve closing

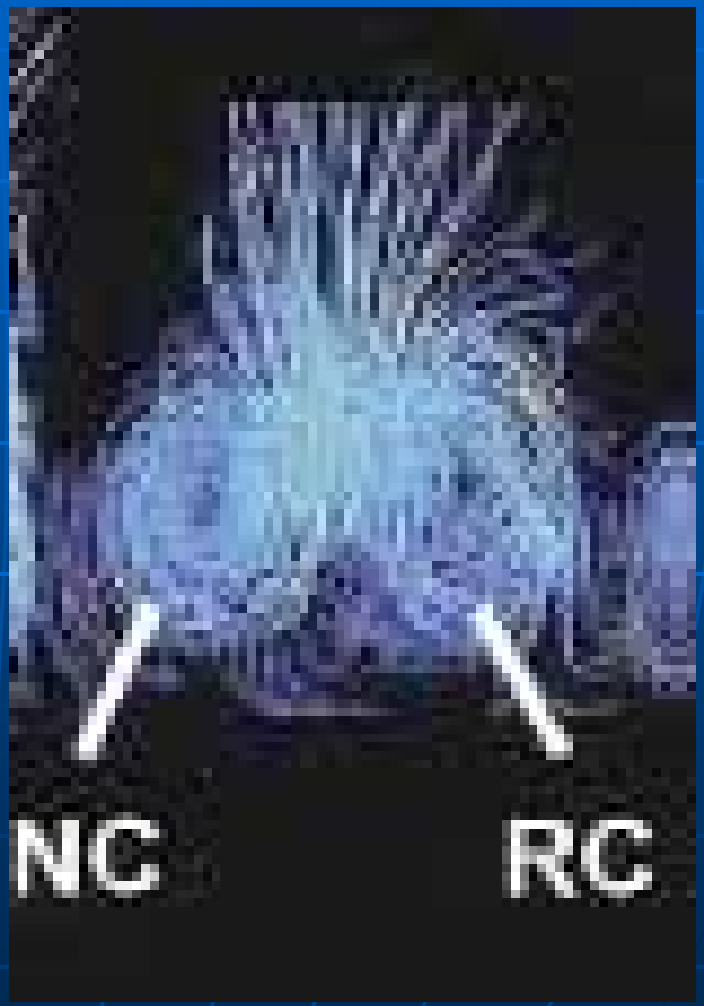



Schematic drawing of an M-mode tracing describing the measured aortic valve opening and closing features

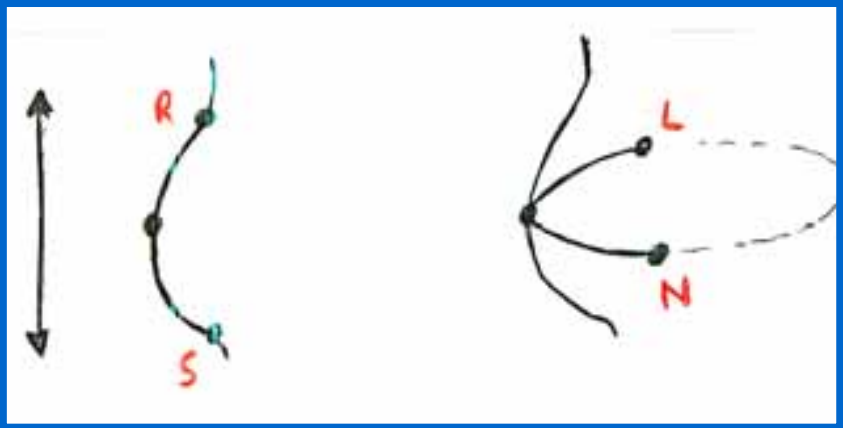
## Old technique
## “by hand”

Royal Library, Windsor 19117v.

## New technique
## “phase contrast MRI”

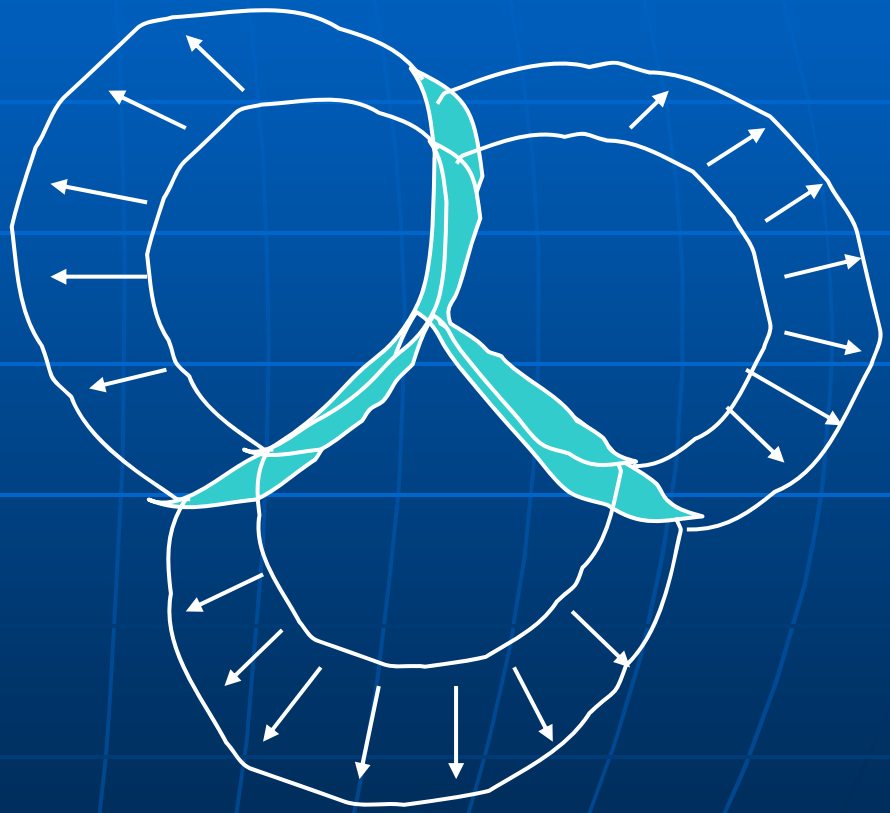


# Concept of the functional unit sinus-cusp




Shock absorbing

Stress sharing



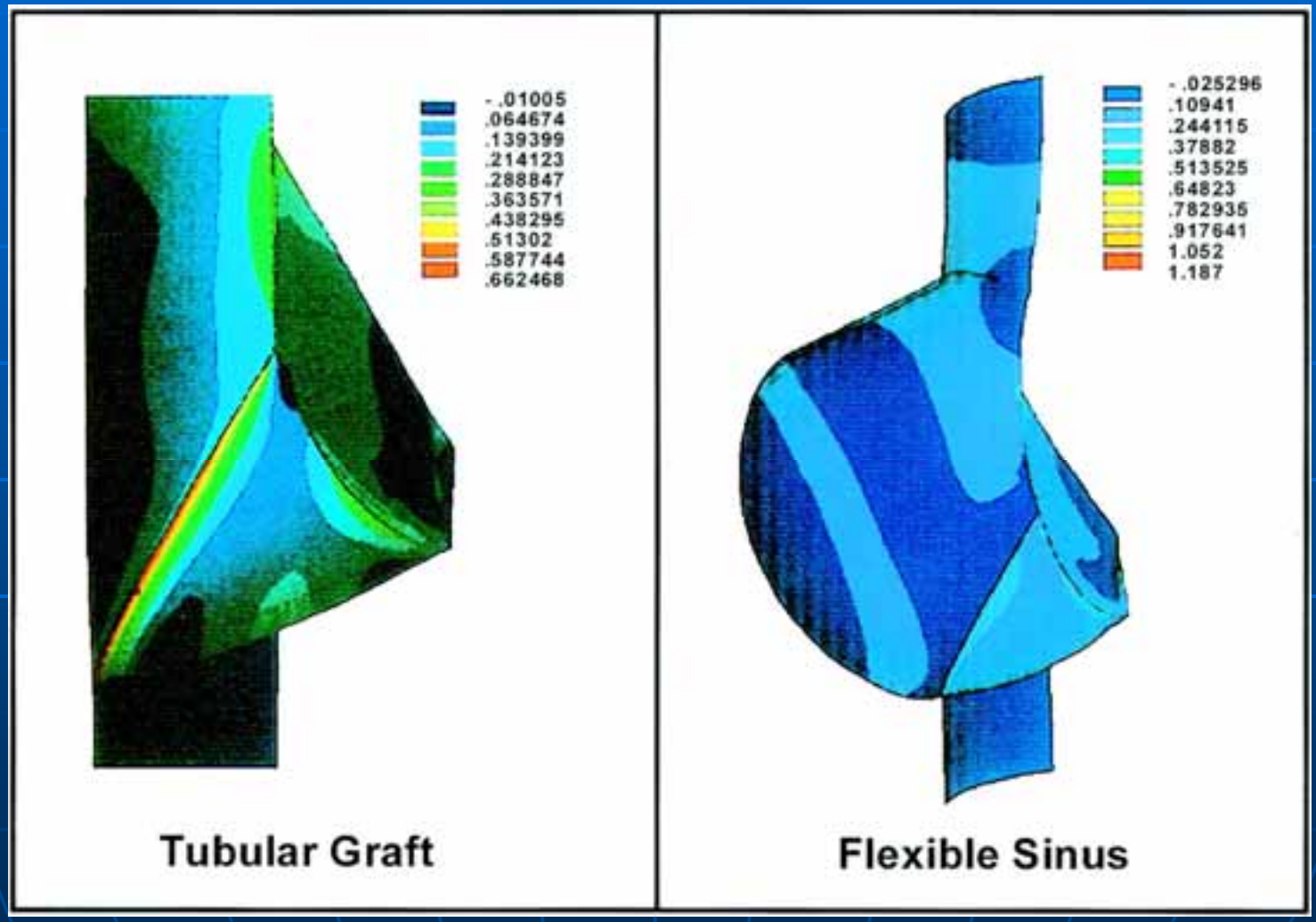
# Stress and aortic valve

At 100 mmHg the aortic valve withstand a pressure of:

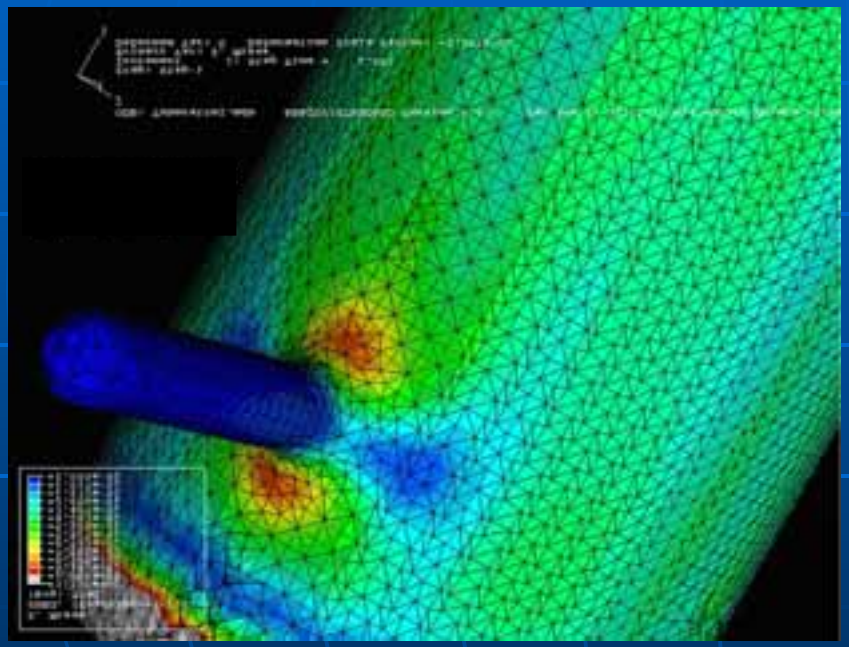
- ✓ 1,3 Kg vertically
- ✓ 0,6 Kg horizzontally (200 g for each commissure)

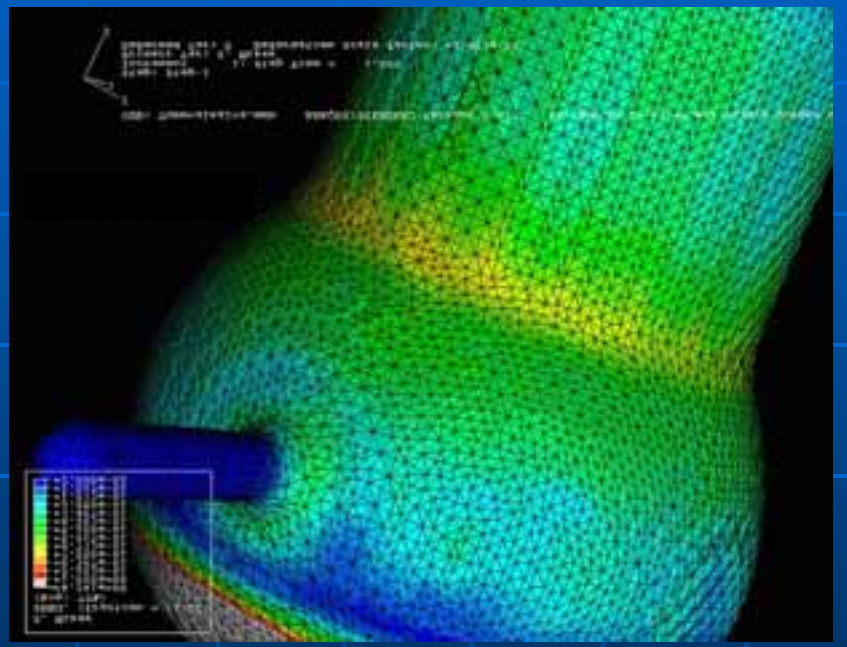
***Elasticity is an important variable specially at sinus level***

# Stress contours in the aortic root when the flexible sinuses are present versus when the sinuses are absent

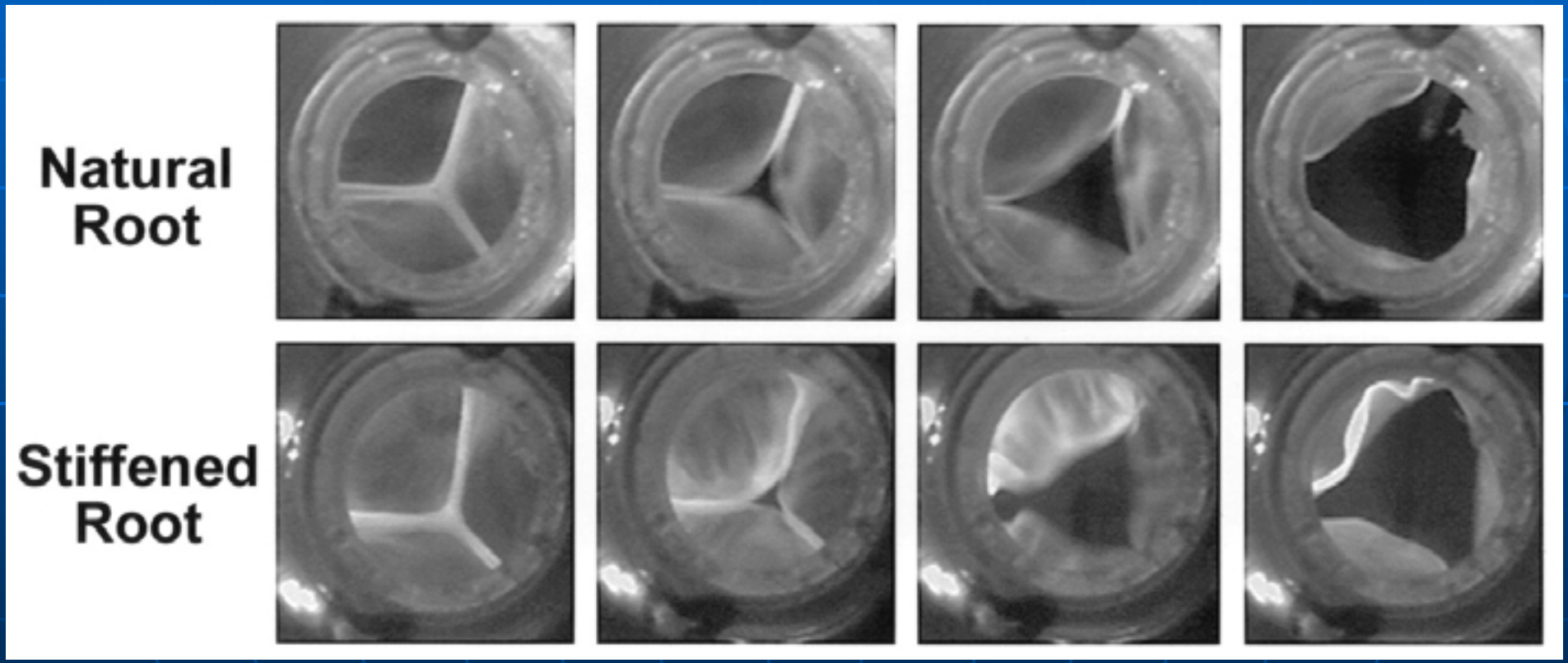



Robicsek F. et al. Ann Thorac Surg 2002;73:1346-1354



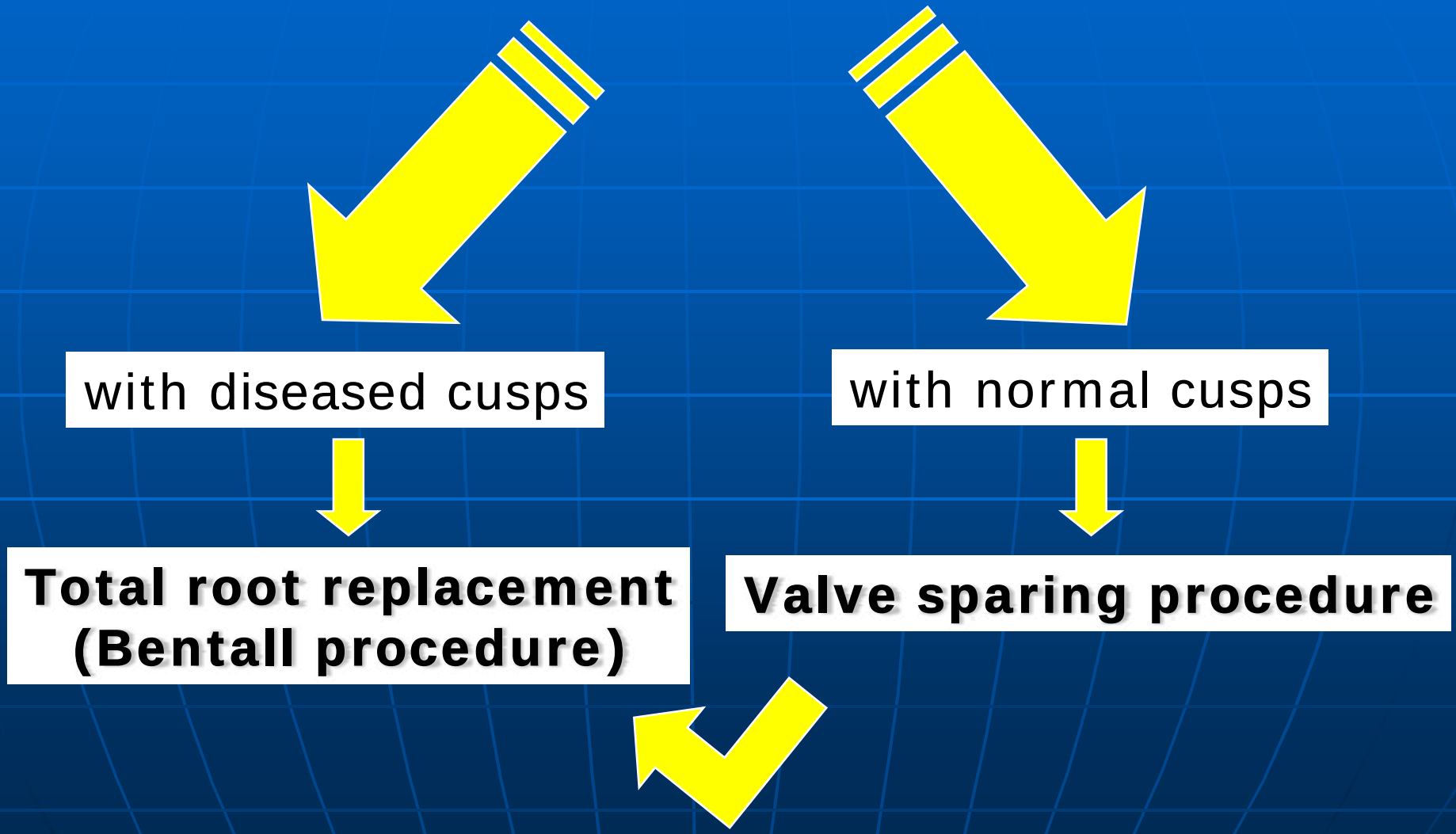


# Five hundred frames/sec cinematography showing the leaflet surface during valve opening




Robicsek F. et al. Ann Thorac Surg 2002;73:1346-1354

# Pathology of the aortic root



# Valve sparing procedures

1. **Resuspension**
2. **Remodeling (Yacoub 1983)**
   - ✓ Robicsek
   - ✓ Urbanski
   - ✓ The tailor of Gloucester
   - ✓ The Florida sleeve
   - ✓ Hopkins
   - ✓ Lansac
3. **Reimplantation (David 1992)**
   - ✓ Cochran sinus reconstruction
   - ✓ The David's number (I to V)
   - ✓ The Stanford modification (David V)
   - ✓ Gleason
   - ✓ The Valsalva graft
     - *Cameron technique*
     - *Mazzola modification*
     - *Maselli adjustable ST junction*

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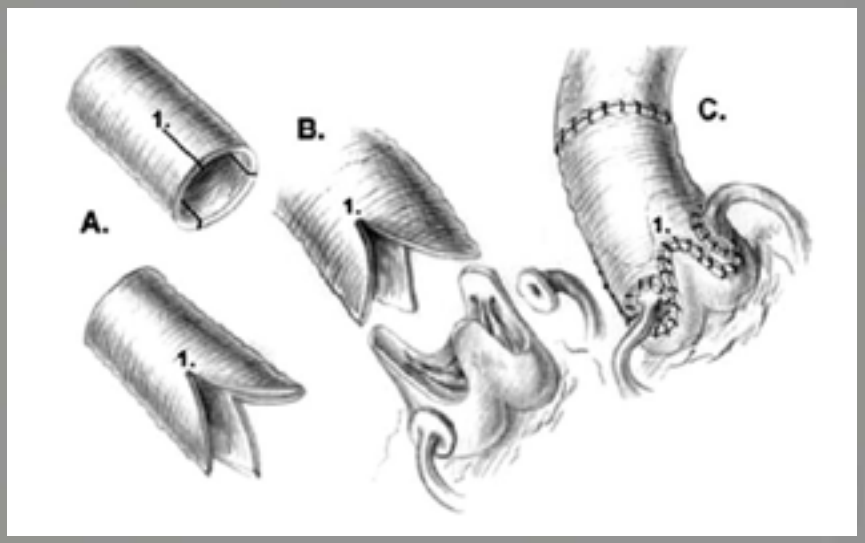
# Remodeling




a

b

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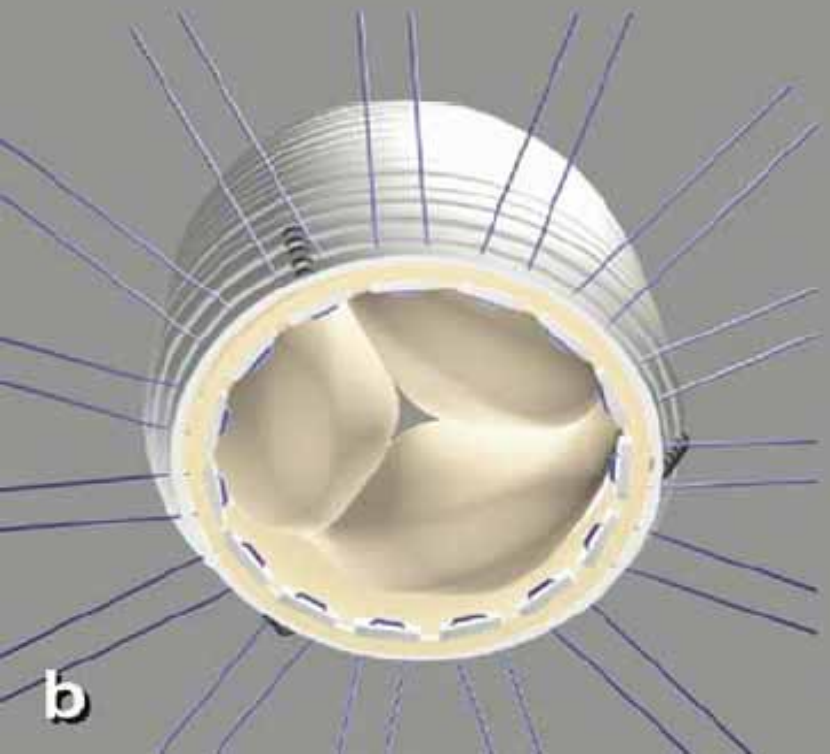
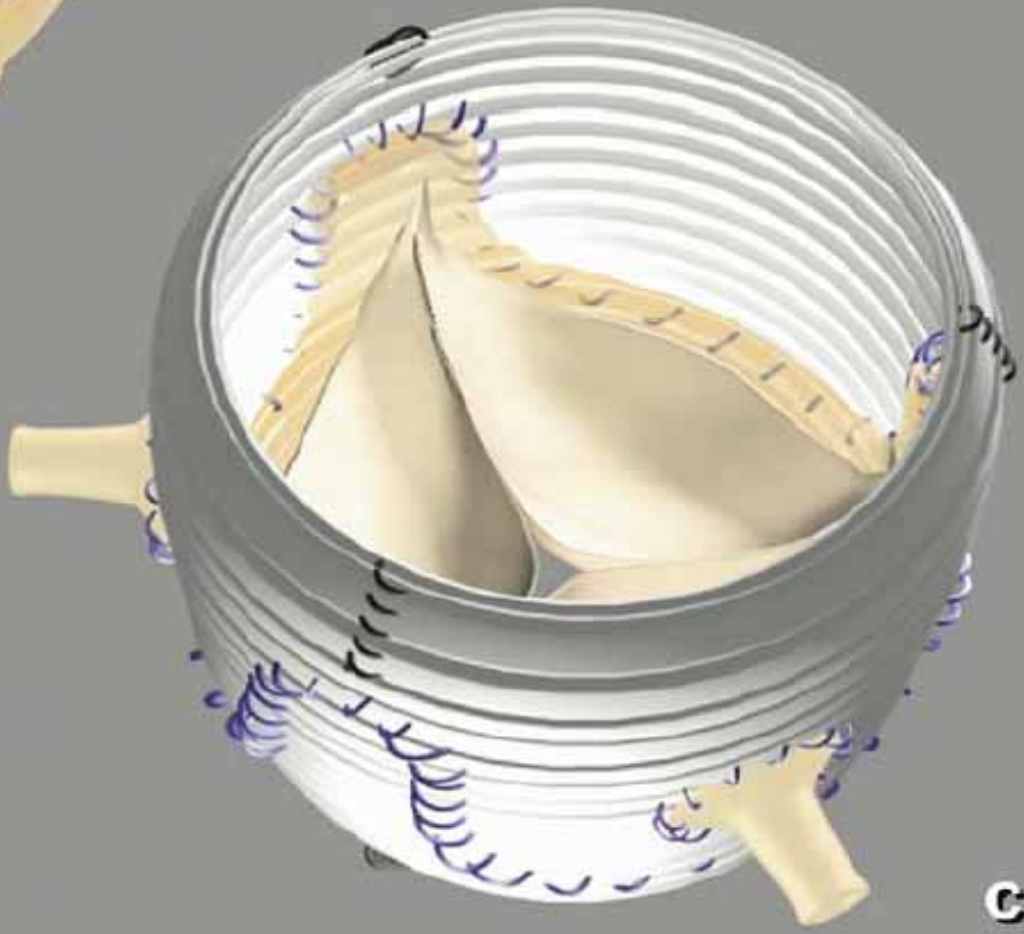
# Reimplantation

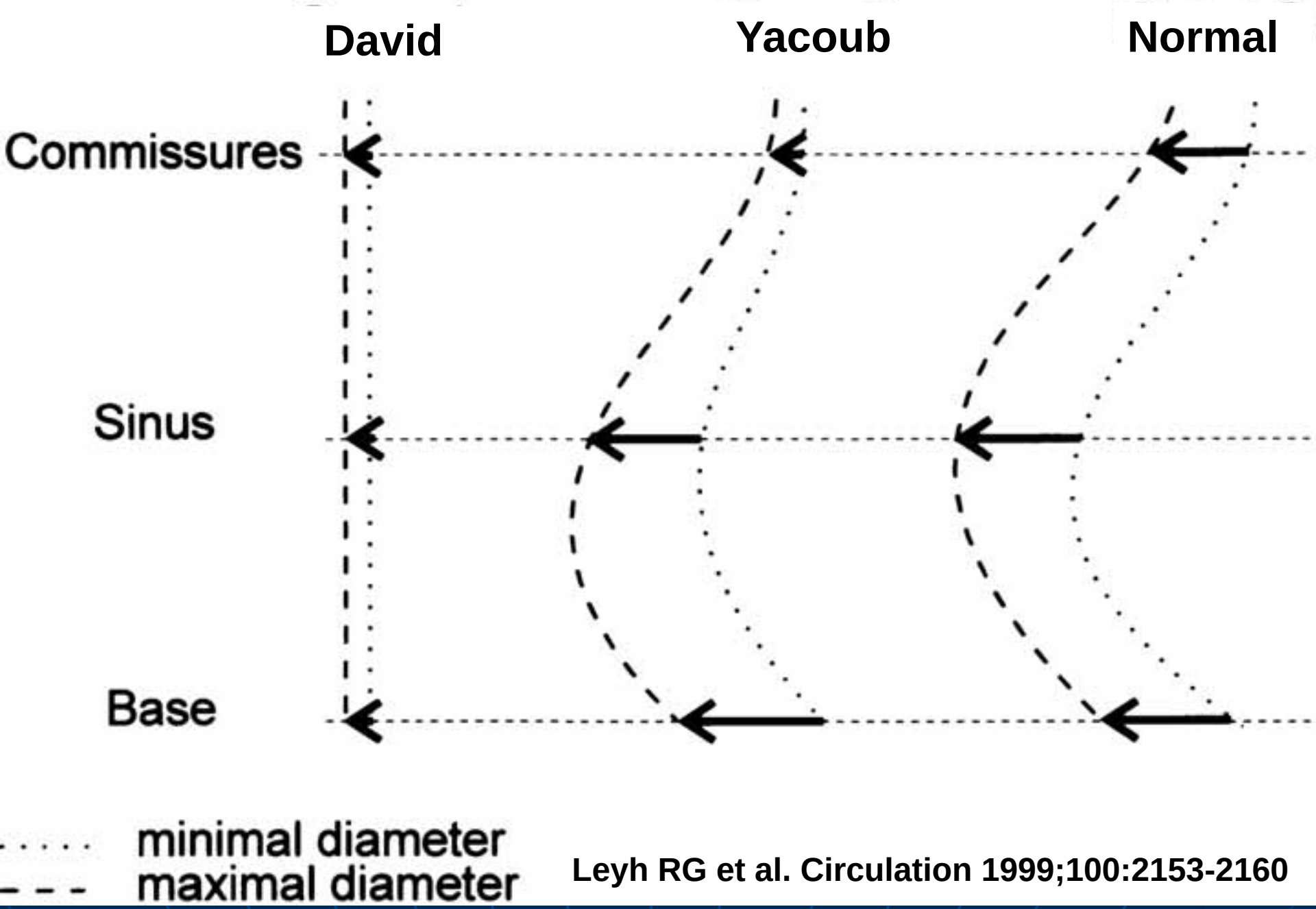
a



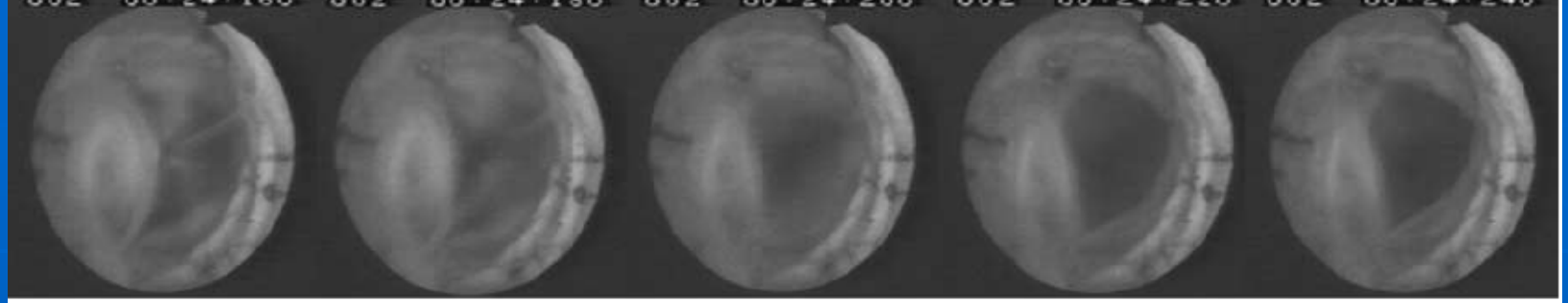
b



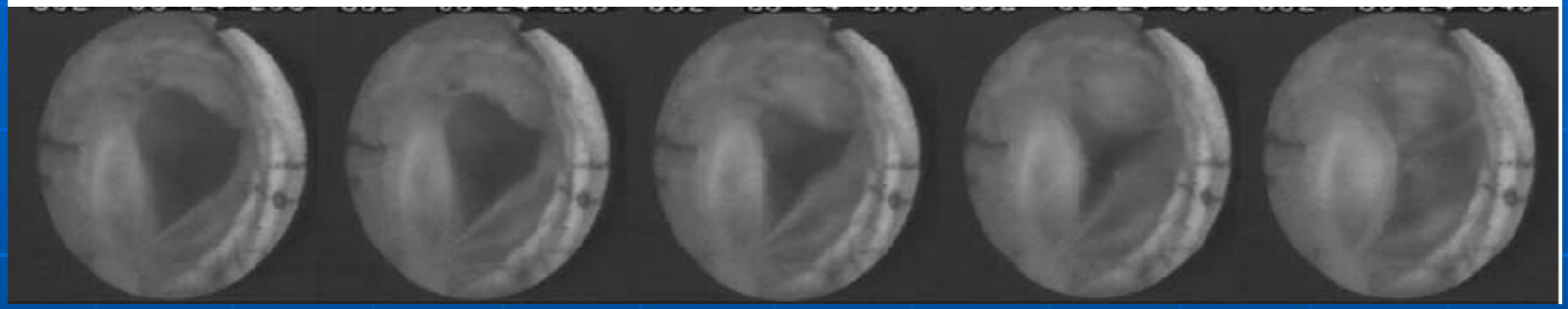
c




Leyh RG et al. Circulation 1999;100:2153-2160



**REMODELING**



Furukawa K et al. Ann Thor Surg 2004;77:1636-41

**REIMPLANTATION**

# The Valsalva graft standardize while combining remodeling and reimplantation

1. Annulus stabilization
2. Support of the aortic wall
3. Less risk of suture bleeding

**+**

**Reconstruction of sinuses of normal shape and dimension**

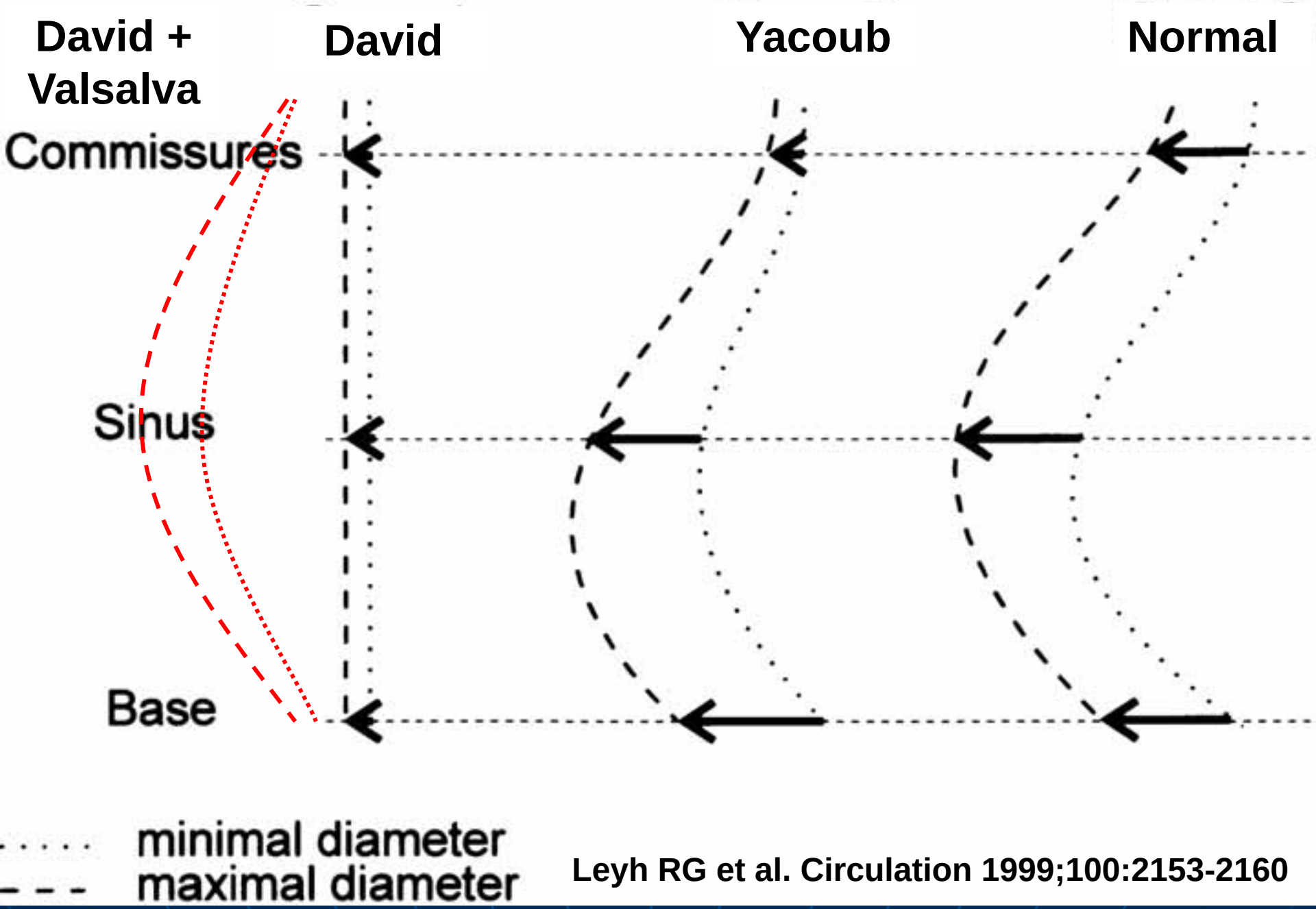
Normal root proportion

ST junction re-established

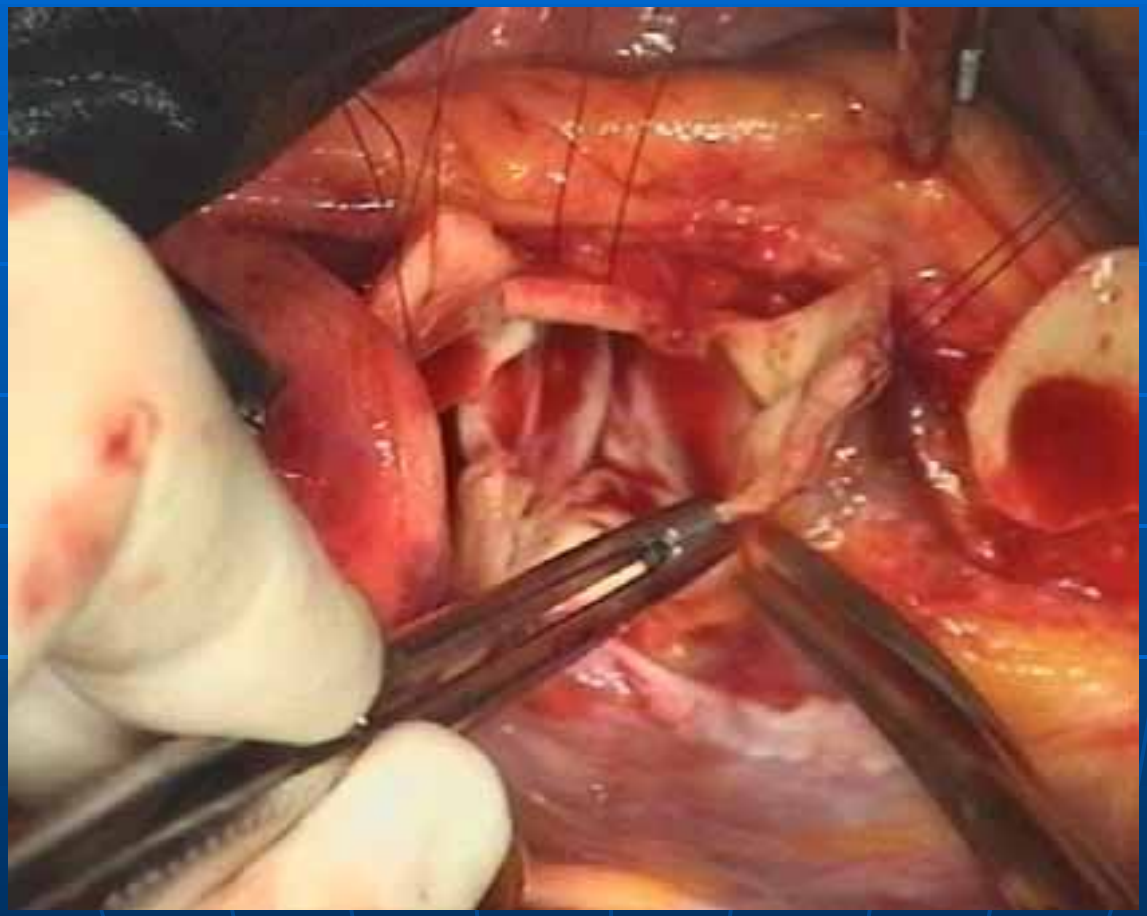
Individual
Sinus expansion

Interleaflet triangle

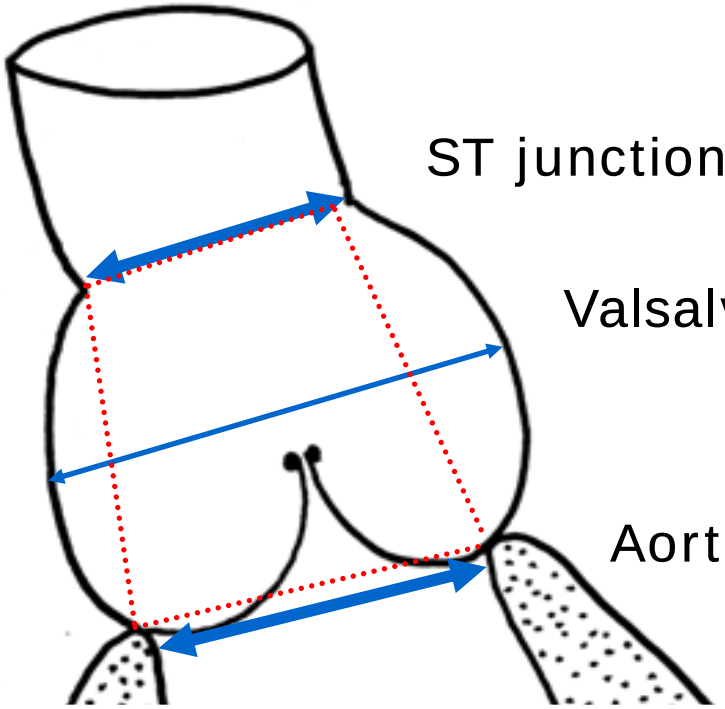
Coaptation height and length




Leyh RG et al. Circulation 1999;100:2153-2160



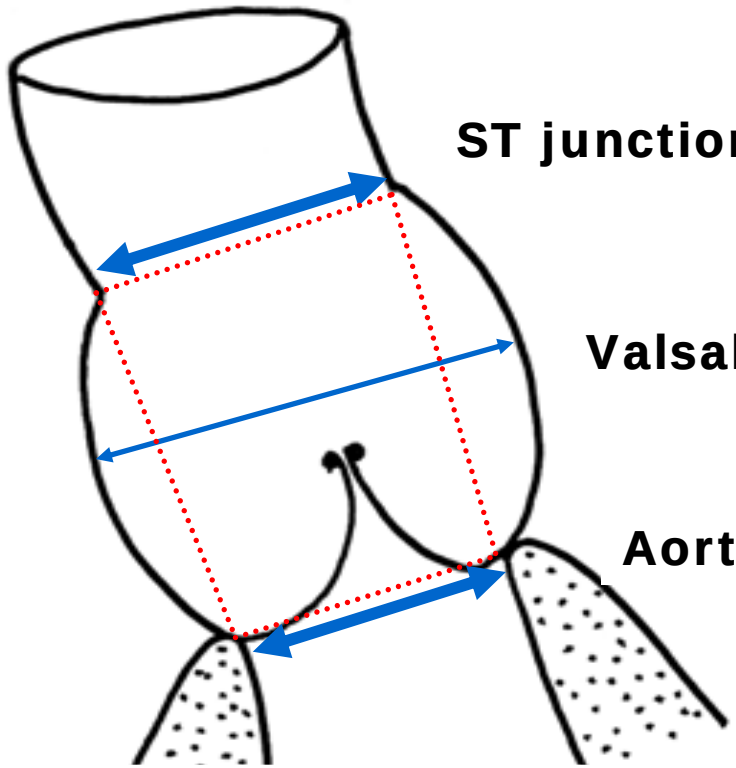
# Normal anatomy (nonpressurized)




AORTIC ANNULUS
**>** ST JUNCTION
**with a 1 to 1.15 ratio**

Acar C. 6th Symposium on aortic and mitral reconstructive surgery. Brussels 2006

# Echocardiographic anatomy




AORTIC ANNULUS
< ST JUNCTION

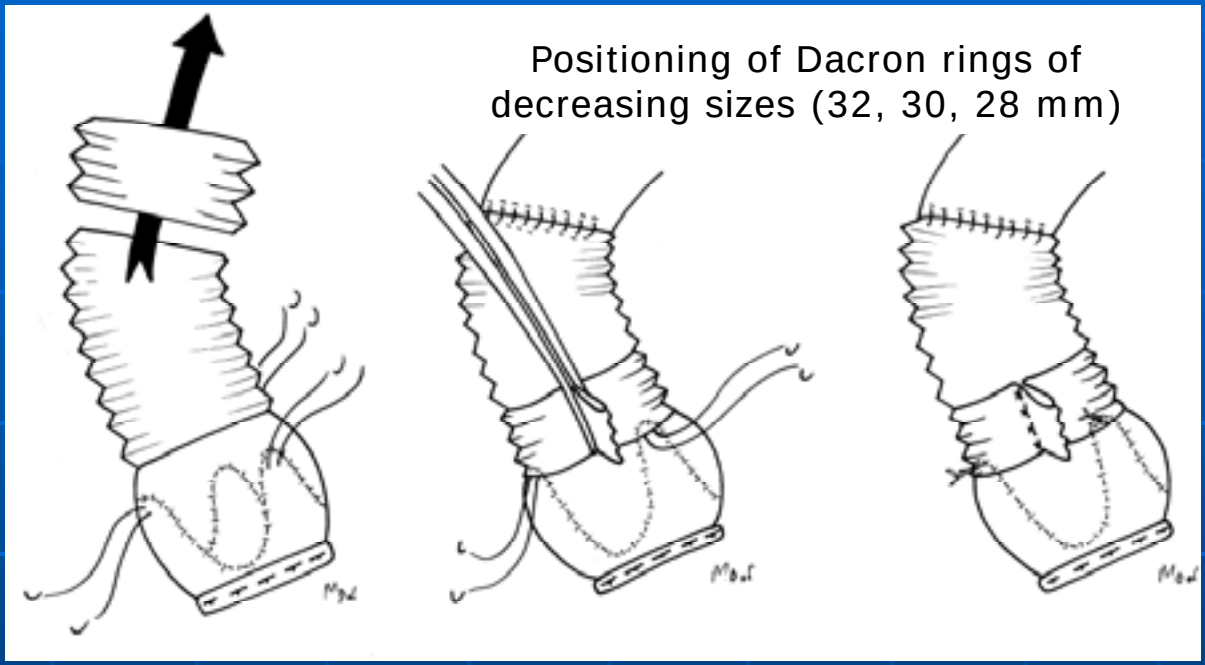
*The sinotubular junction is <u>larger</u> than the annulus with a diameter **ratio of 1.3** in a normal adult human heart*

Acar C. 6th Symposium on aortic and mitral reconstructive surgery. Brussels 2006

# Echocardiographic anatomy

| valve size | average leaflet length | average sinus height | average coaptation height |
|---|---|---|---|
| 21 (n=4) | 21.3 mm (20.6-21.8) | 21.4 mm (20.9-22.0) | 11.2 mm (10.8-12.6) |
| 22 (n=2) | 22.2 mm (21.8-22.5) | 22.3 mm (22.1-22.6) | 11.7 mm (11.4-12.0) |
| 23 (n=6) | 23.4 mm (22.6-24.0) | 23.2 mm (22.7-23.8) | 12.3 mm (11.6-12.8) |
| 25 (n=2) | 25.3 mm (25.2-25.5) | 25.1 mm (25.0-25.3) | 12.9 mm (12.7-13.1) |

V. Vijay et al. EACTS/ESTS Joint Meeting 2000



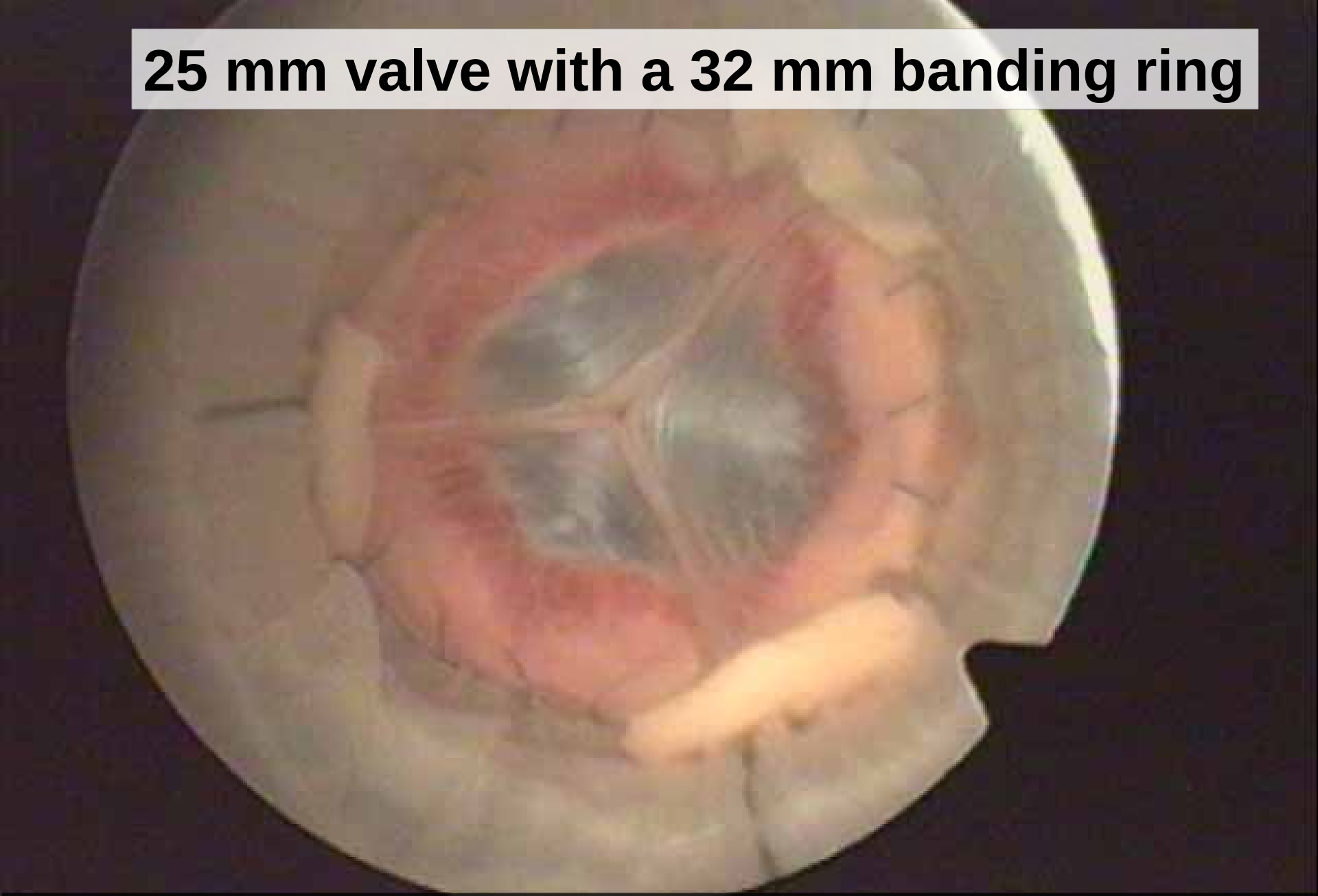

25 mm porcine valve sutured into the dilated portion of a 32 mm Valsalva graft

(Ann Thorac Surg 2007;84:1214–8)

# 25 mm valve without STJ banding ring

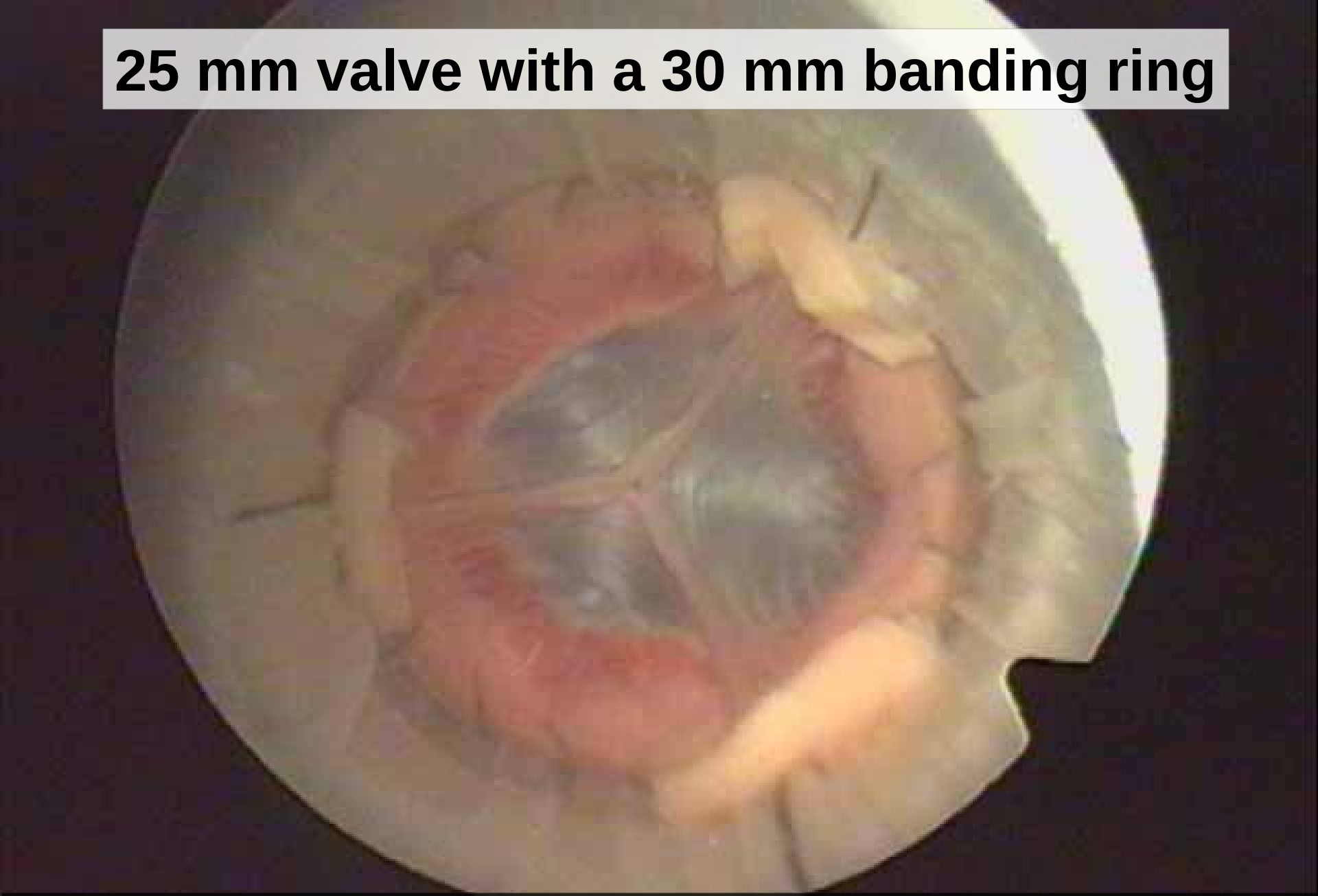
Commissures are displaced centrifugally.
A central orifice is evident. Leaflets tethering and outward bending of the leaflet free margin are evident.

# 25 mm valve with a 32 mm banding ring



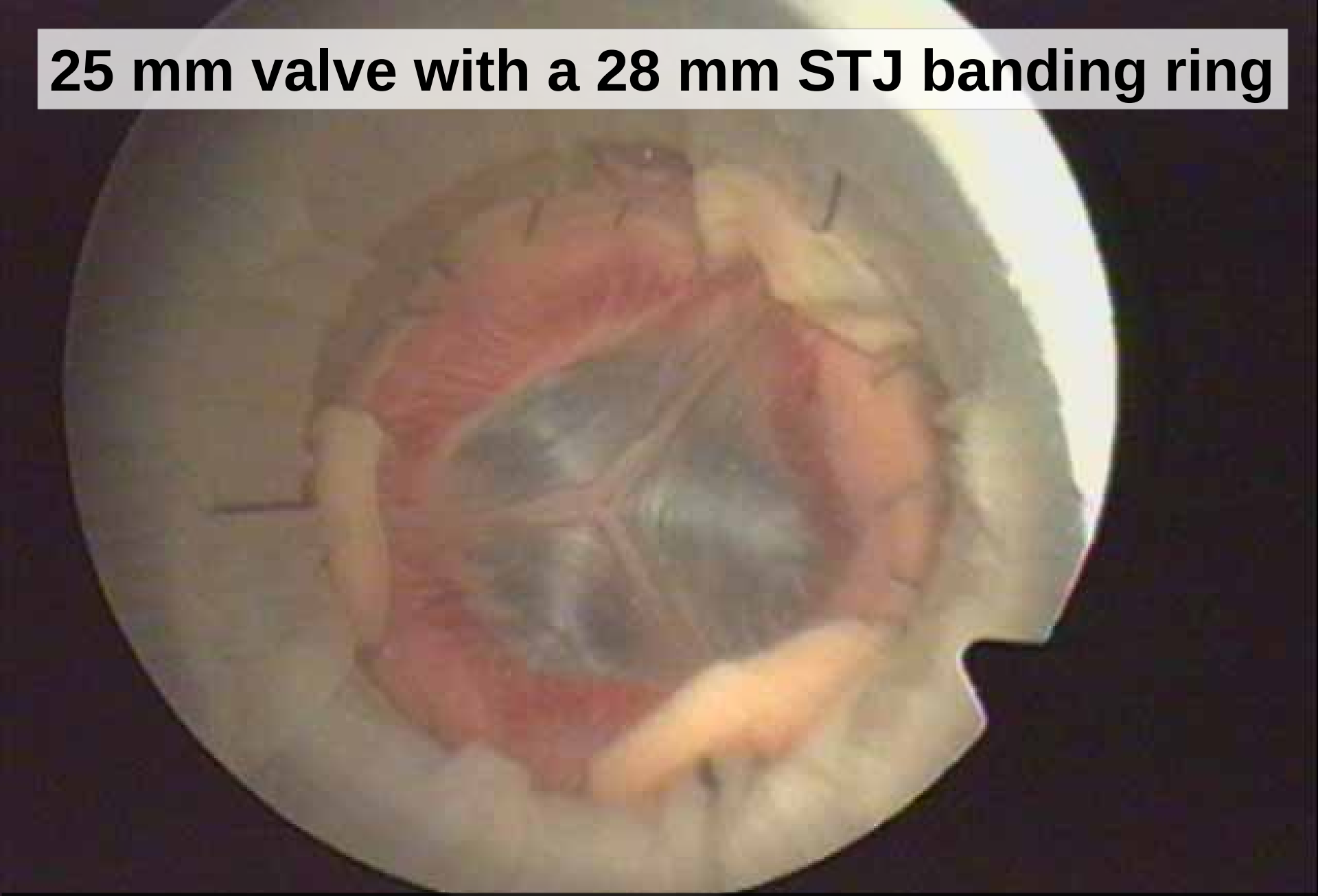
The central orifice is reduced. Leaflets tethering and free margin bending are also reduced but not eliminated.

# 25 mm valve with a 30 mm banding ring



The central orifice has disappeared.
Leaflets coaptation is optimized.

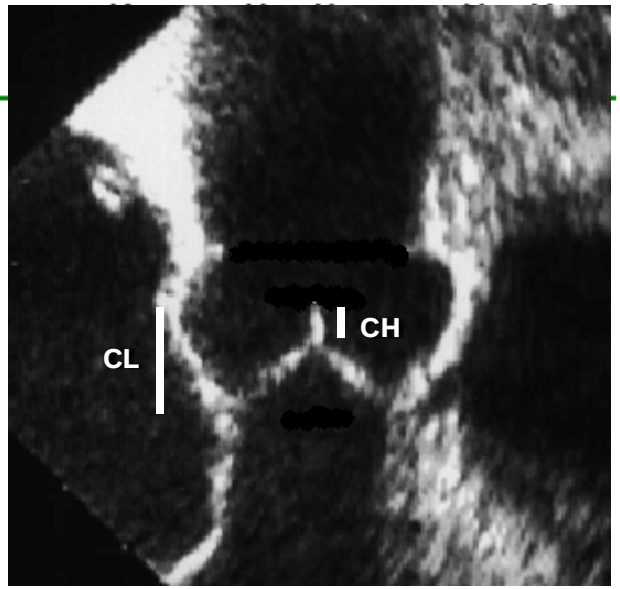
# 25 mm valve with a 28 mm STJ banding ring



The central orifice has disappeared.
Leaflets coaptation is optimized but…

# Reconstructed leaflet anatomy

| | Wrapping Ring Size | | | | p value | p value | p value |
|---|---|---|---|---|---|---|---|
| | None | 32 mm | 30 mm | 28 mm | | | |
| SD (mm) | 38.2±0.6 | 34.1±0.5 | 33.6±0.5 | 33.2±0.4 | | | |
| STJD (mm) | 37.6±0.5 | 30.6±0.5 | 29.2±0.6 | 26.9±1 | | | |
| CH (mm) | 7.6±0.6 | 9.5±0.6 | 10.6±0.6 | 7.7±0.4 | | | |
| CL (mm) | 18.6±0.2 | 18.6±0.5 | 16.5±0.4 | 8.2±1.3 | | | |

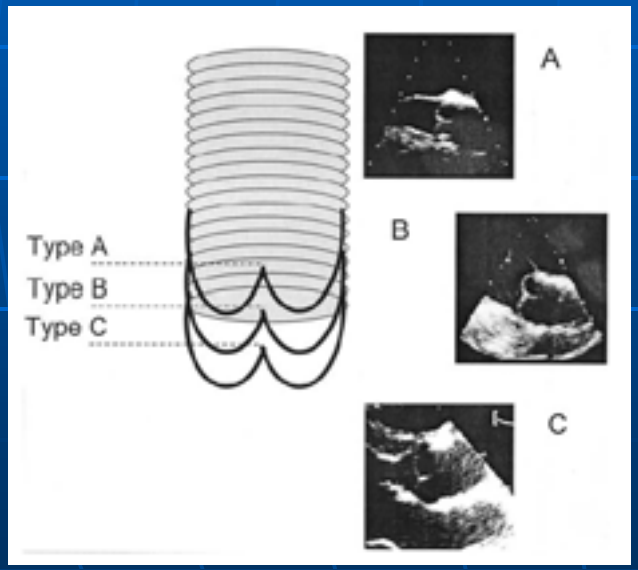


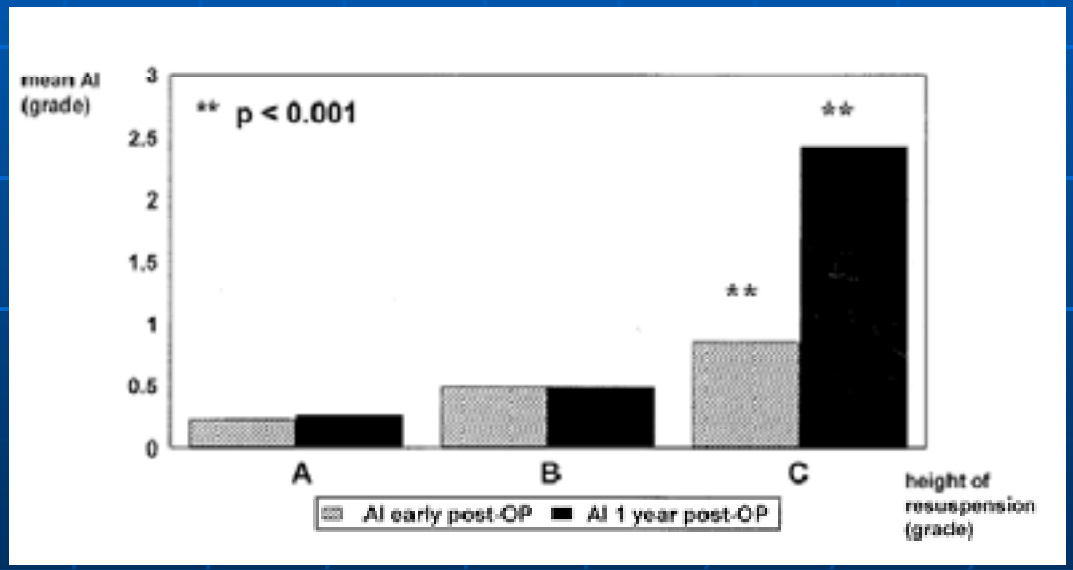

SD = sinuses diameter, STJD = sinotubular junction diameter, CH = coaptation height, CL = coaptation level.

# Aortic Valve Reimplantation in Ascending Aortic Aneurysm: Risk Factors for Early Valve Failure

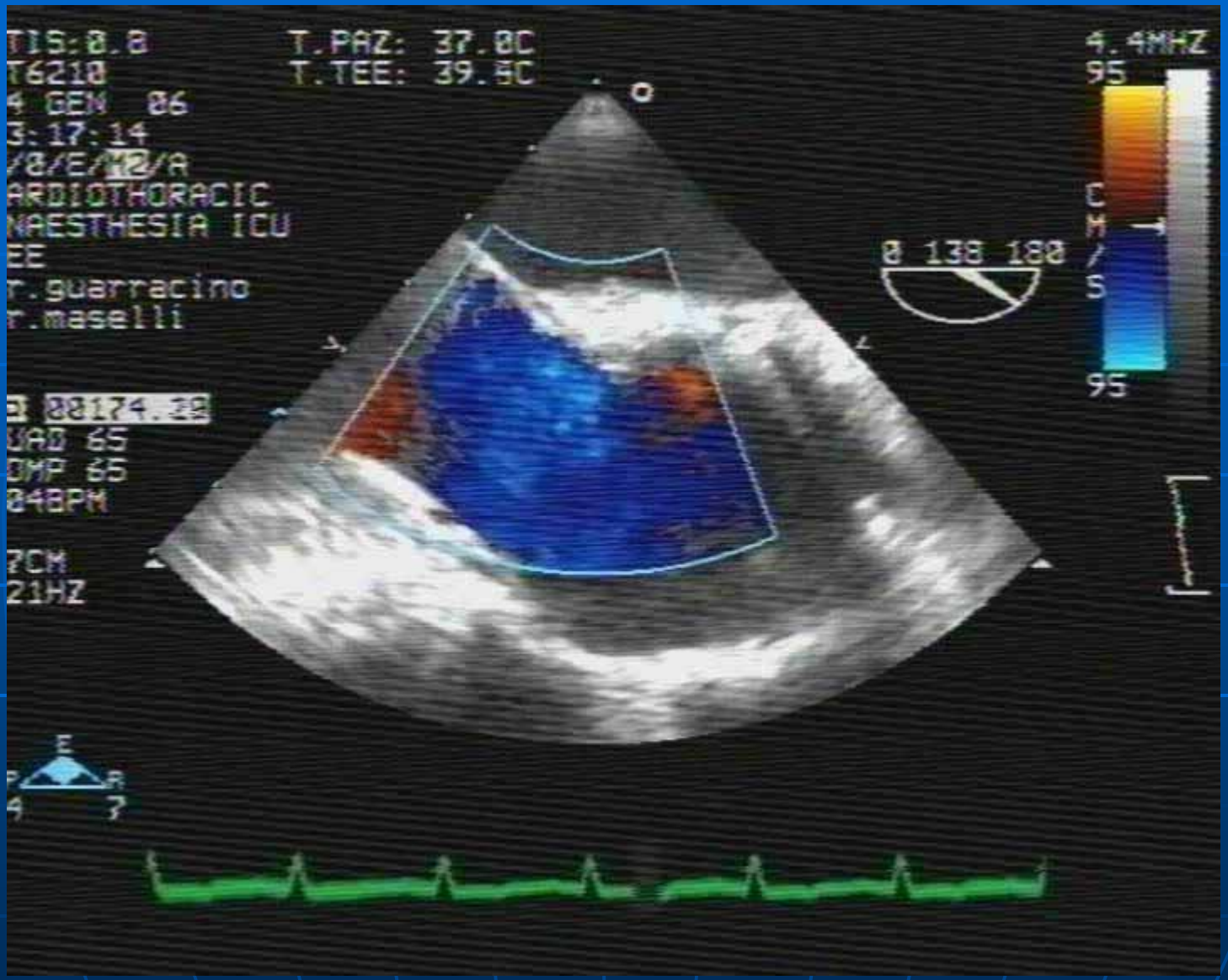
Klaus Pethig, MD, Andrea Milz, Christian Hagl, MD, Wolfgang Harringer, MD, and Axel Haverich, MD

Department of Thoracic and Cardiovascular Surgery, Division of Surgery, Hannover Medical School, Hannover, Germany




*Ann Thorac Surg* 2002;73:29-33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OMP 65
04BPM
7CM
21HZ
T.PAZ: 37.0C
T.TEE: 39.5C
4.4MHZ
95
CM/S
95
0 138 180
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7

*“Anchorache lo ingegno umano faccia inuentioni varie rispondendo con uari strumenti a un medesimo fine mai esso trovera inuentione piu bella ne piu facile ne piu breue della Natura perche nelle sue invenzioni nulla manca e nullo e superfluo”*

“Though human ingenuity might make various inventions which by the help of various machines answering the same end will never device any invention more beautiful, nor more simple, nor more to the purpose than nature does; because in her invention nothing is wanting, and nothing is superfluous”