

la pratica dev' essere edificata sopra la buona teorica  
(Practice must always be founded on sound theory)  
Leonardo Da Vinci

- Technical consideration of acquiring and analyzing 3D TEE volume data sets (EchoPac®)
- Phasic changes of the aortic root throughout the cardiac cycle
- Specific application in aortic regurgitation and aortic root/ascending aorta pathology

PROG

## Reconstruction of the Aorta A practical approach

■ Wednesday, May 20<sup>th</sup> to Friday

Location  
University Hospital of Saarland  
Homburg/Saar, Germany

Chairman  
Prof. Hans-Joachim Schäfers

Day 2

07.45	Case presentations Live operations: Moderation E. Lansac / T. Doenst	
08.15	Case #1	
09.30	Case #2	
10.15	Bicuspid aortic valve repair and aortopathy	E. Raanani
	<b>BREAK</b>	
11.15	Case #3	
12.45	Discussion of the cases	
	<b>BREAK</b>	
13.30	Reimplantation should be the standard technique	E. Raanani
13.50	Remodeling should be the preferred root repair	E. Lansac
14.15	3-dimensional echo in aortic valve analysis	W. Fehske
	<b>BREAK</b>	
15.00	How to start root remodeling	H.-J. Schäfers
	<b>BREAK</b>	
15.30	Wetlab (bring your loupes!)	Faculty
18.00	Adjourn	



des Saarlandes

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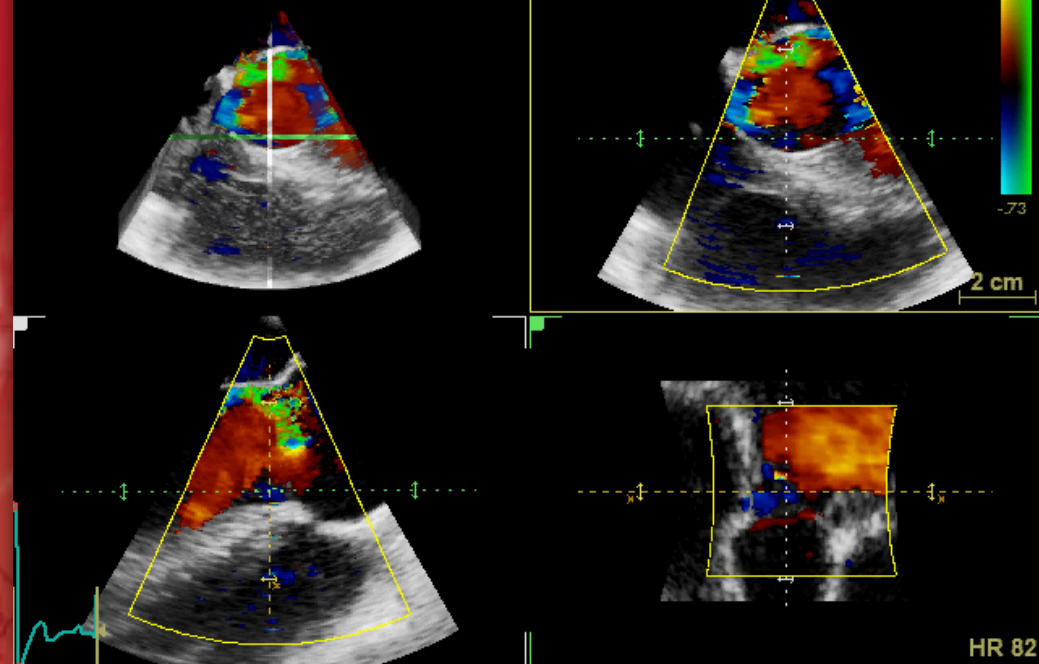
Location  
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Universitätsklinikum  
 des Saarlandes

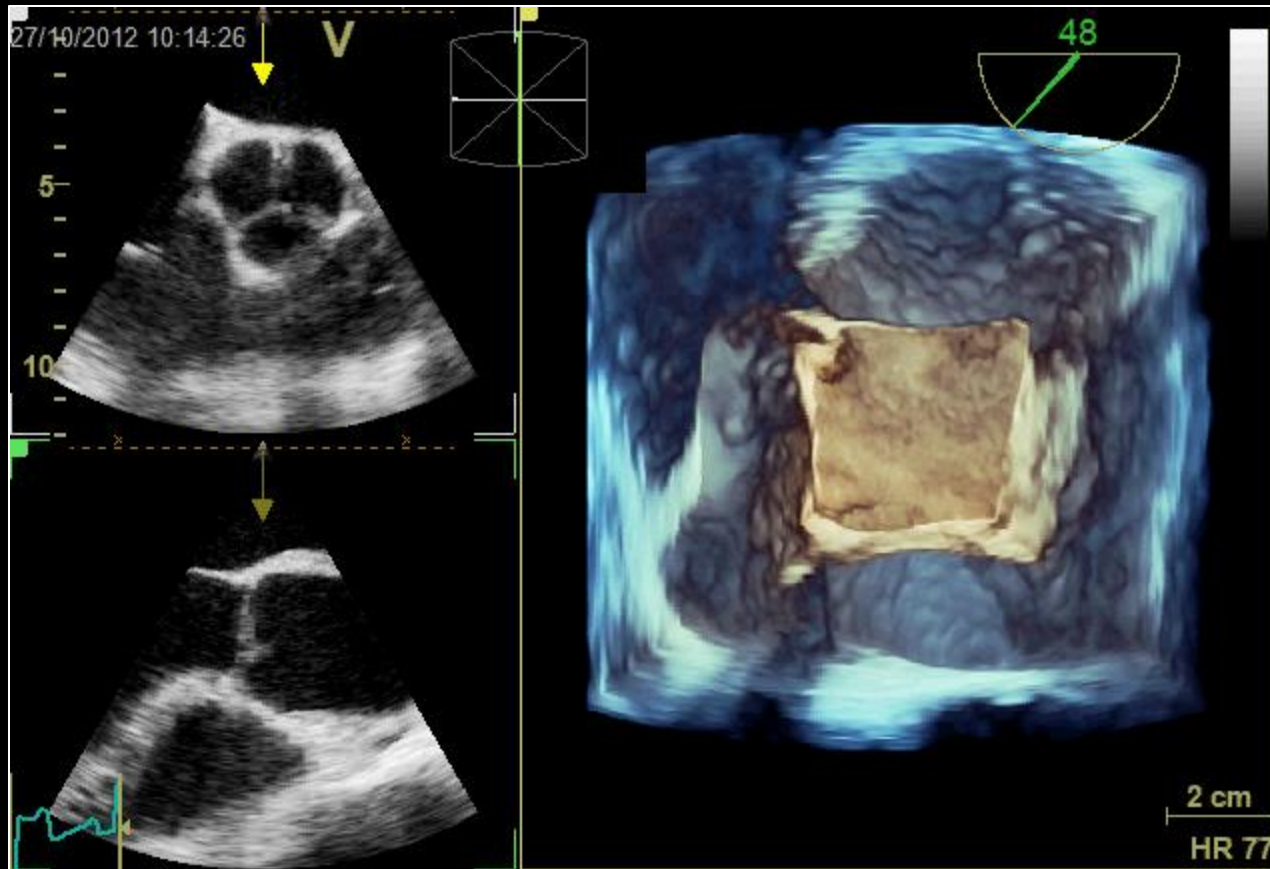
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Day 2

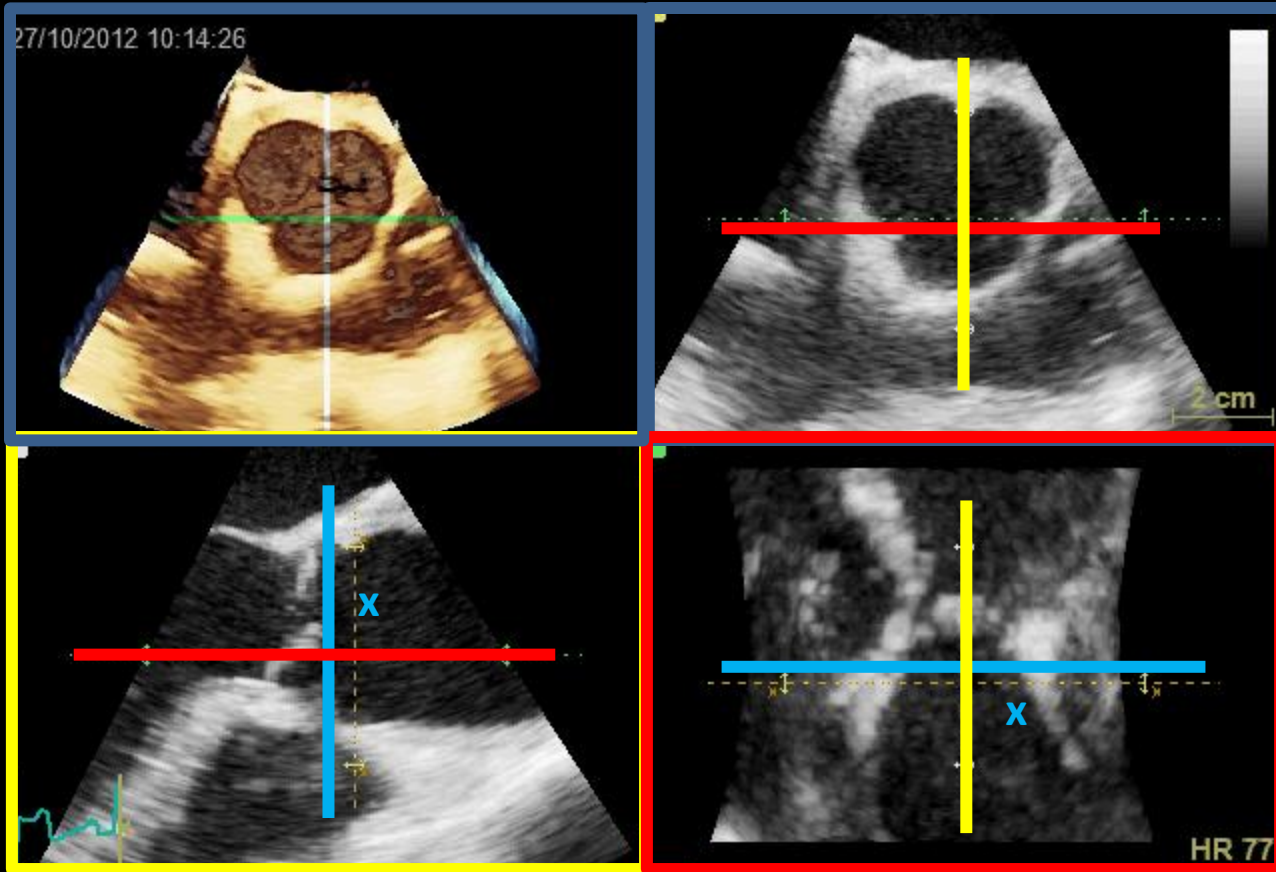
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# 3D TEE data acquisition aortic root

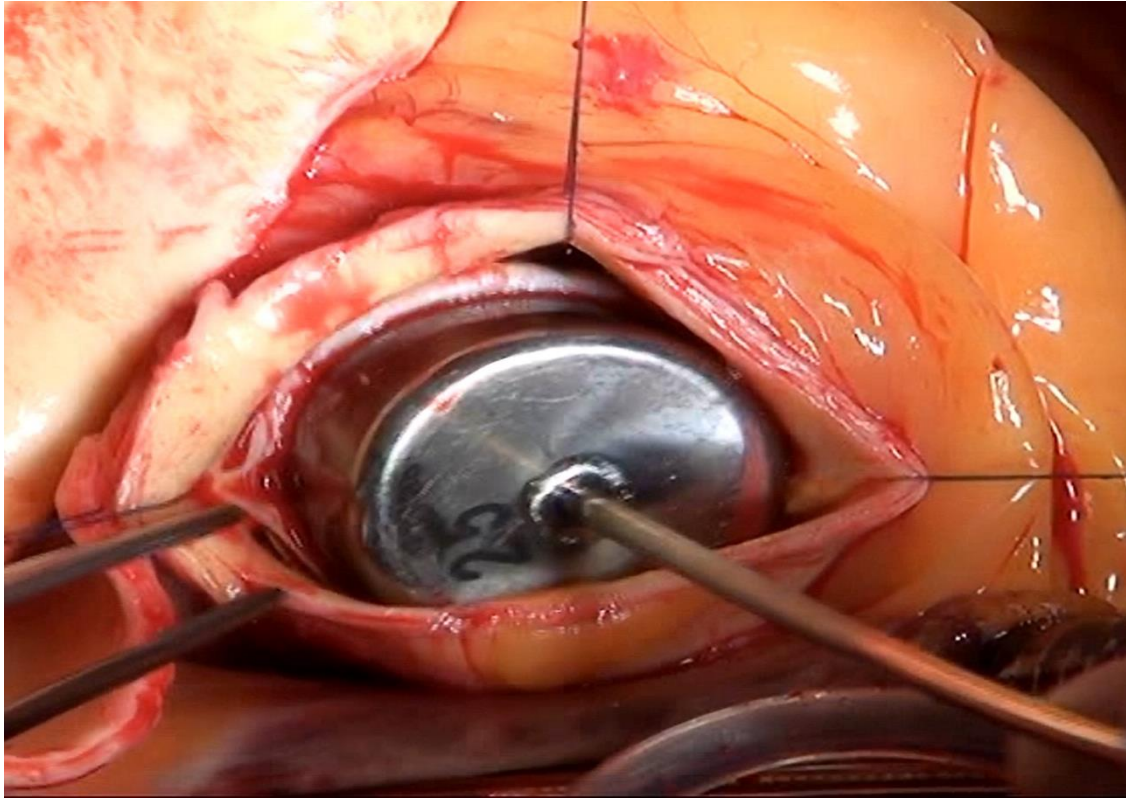




- three orthogonal planes simultaneous
- one plane (to select) 3D surface rendered

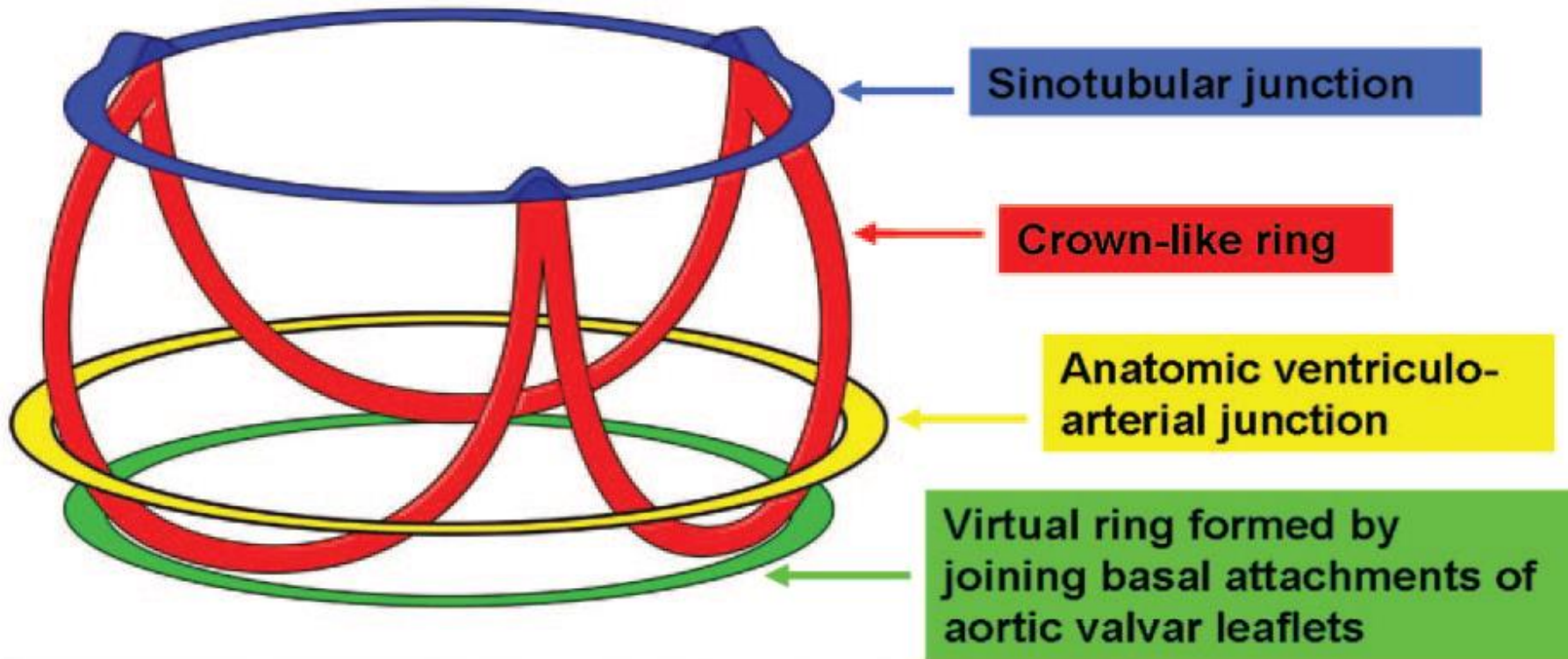


Aortic „ring“ size



Reconstruction of the Aortic Valve  
and Root, Homburg  
2013 May 15th/16th/17th Case 2  
Prof. Schaefers

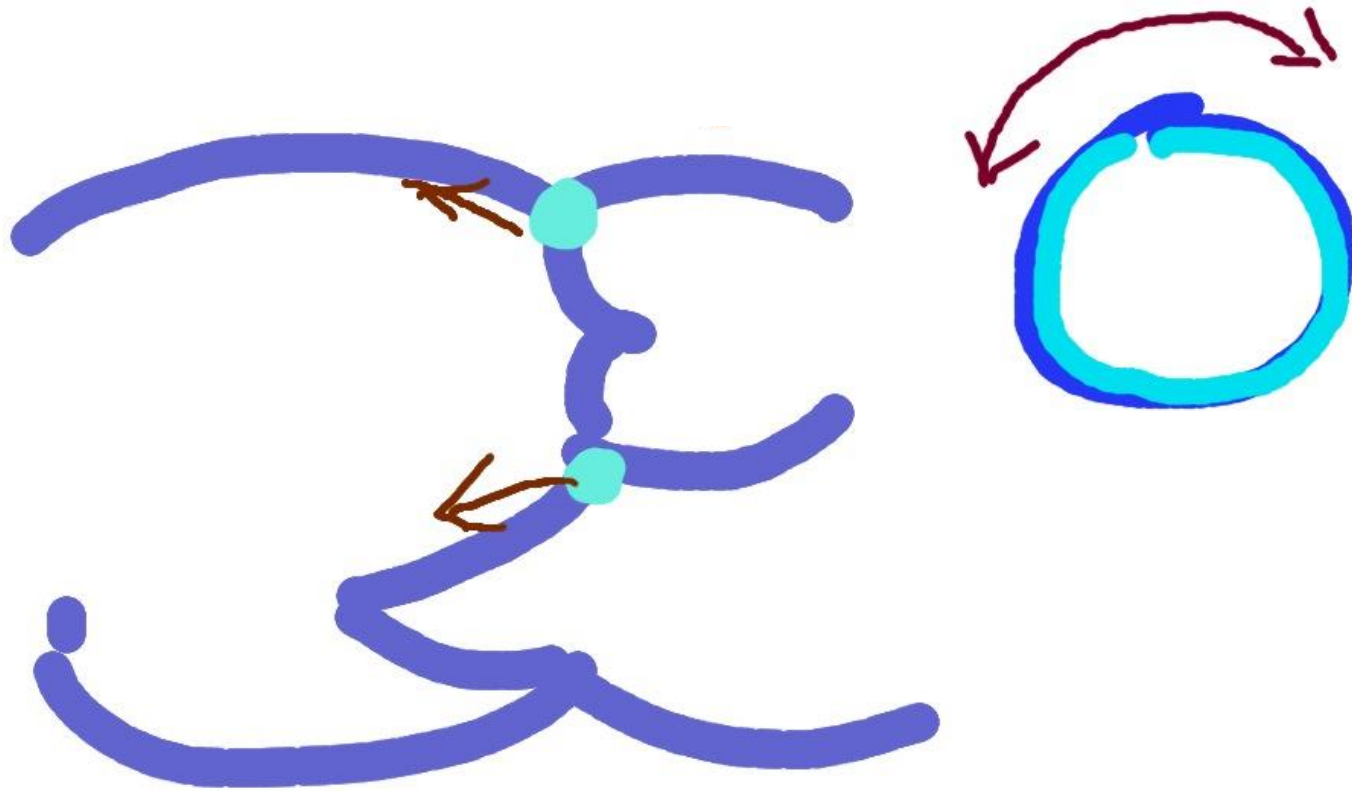
**Figure 4. A, Three-dimensional arrangement of the aortic root, which contains 3 circular “rings,” but with the leaflets suspended within the root in crown-like fashion.**



Piazza N et al. *Circ Cardiovasc Interv* 2008;1:74-81

Rotational and translational movements have to be considered for reliable measurements of the aortic root

Speckle tracking would be ideal for correct measurements throughout the cardiac cycle



# **Automated Quantitative 3-Dimensional Modeling of the Aortic Valve and Root by 3-Dimensional Transesophageal Echocardiography in Normals, Aortic Regurgitation, and Aortic Stenosis**

**Comparison to Computed Tomography in Normals and Clinical Implications**

*(Circ Cardiovasc Imaging. 2013;6:99-108.)*

Anna Calleja, MD\*; Paaladinesh Thavendiranathan, MD, Msc\*; Razvan Ioan Ionasec, PhD;  
Helene Houle, RDCS, RVT; Shizhen Liu, MD, PhD; Ingmar Voigt, MSc; Chittoor Sai Sudhakar, MD;  
Juan Crestanello, MD; Thomas Ryan, MD; Mani A. Vannan, MBBS



**Intercommissural  
Distances**



# **Automated Quantitative 3-Dimensional Modeling of the Aortic Valve and Root by 3-Dimensional Transesophageal Echocardiography in Normals, Aortic Regurgitation, and Aortic Stenosis**

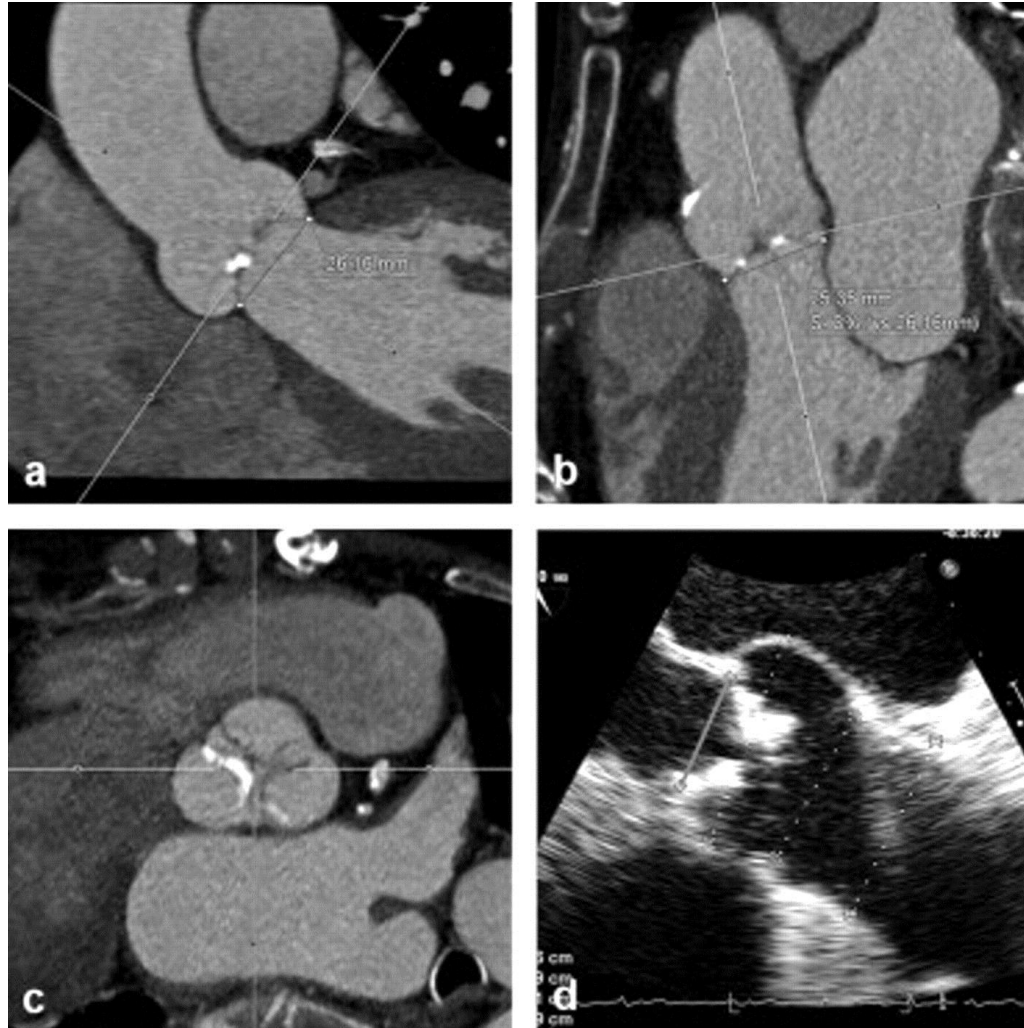
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**'Hinge-to-hinge' assessment: three predefined standard views were reconstructed to assess of aortic annulus anatomy using multiplanar reformatted images adjusted to the axis of the aortic root.**

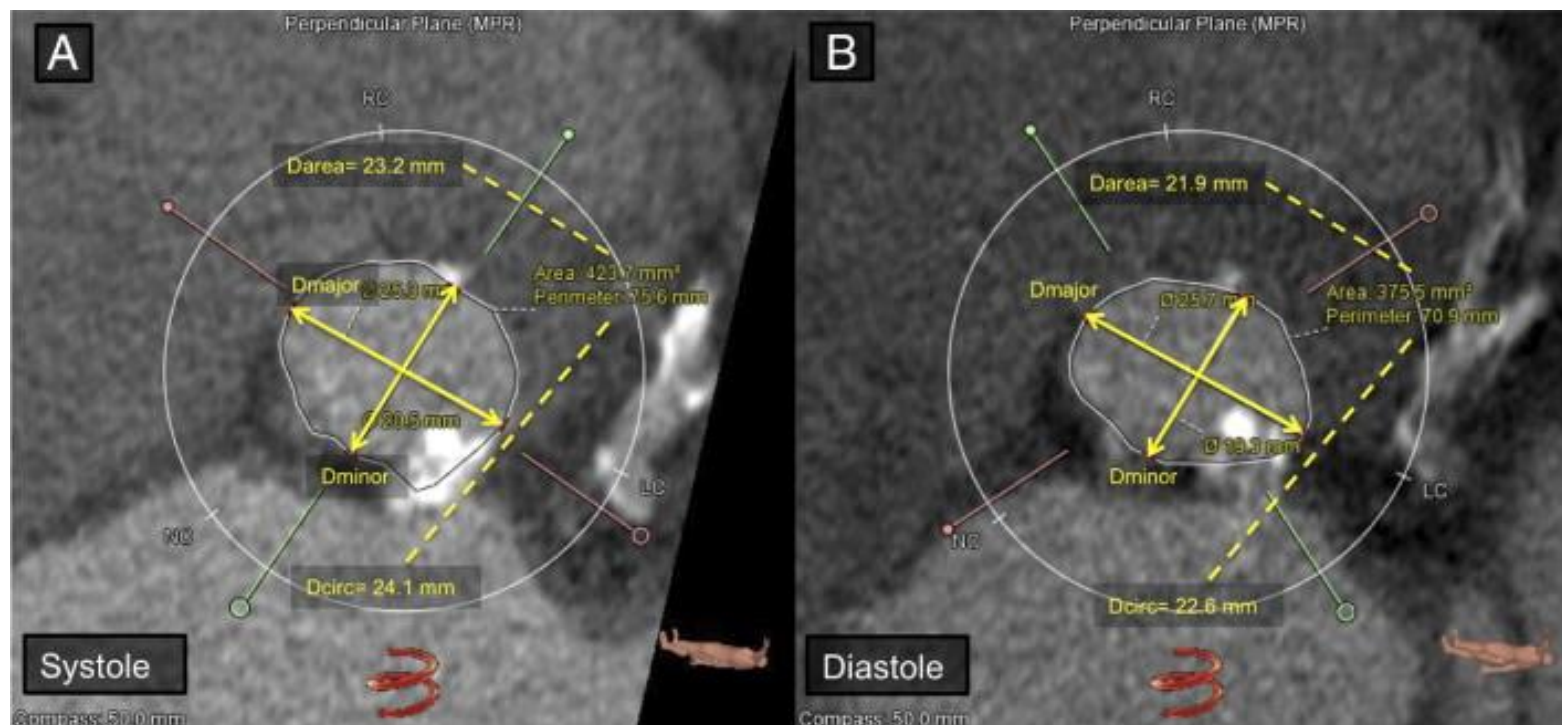


**Blanke P et al. Eur J Cardiothorac Surg 2010;38:750-758**

# Cross-Sectional Computed Tomographic Assessment Improves Accuracy of Aortic Annular Sizing for Transcatheter Aortic Valve Replacement and Reduces the Incidence of Paravalvular Aortic Regurgitation

Hasan Jilaihawi, BSc (Hons), MBChB; Mohammad Kashif, MD; Gregory Fontana, MD; Azusa Furugen, MD, PhD; Takahiro Shiota, MD; Gerald Friede, BS, MS; Rakhee Makhija, MD; Niraj Doctor, MBBS; Martin B. Leon, MD; Raj R. Makkar, MD

*J Am Coll Cardiol.* April 03, 2012,59(14):1275-1286 doi:10.1016/j.jacc.2011.11.045

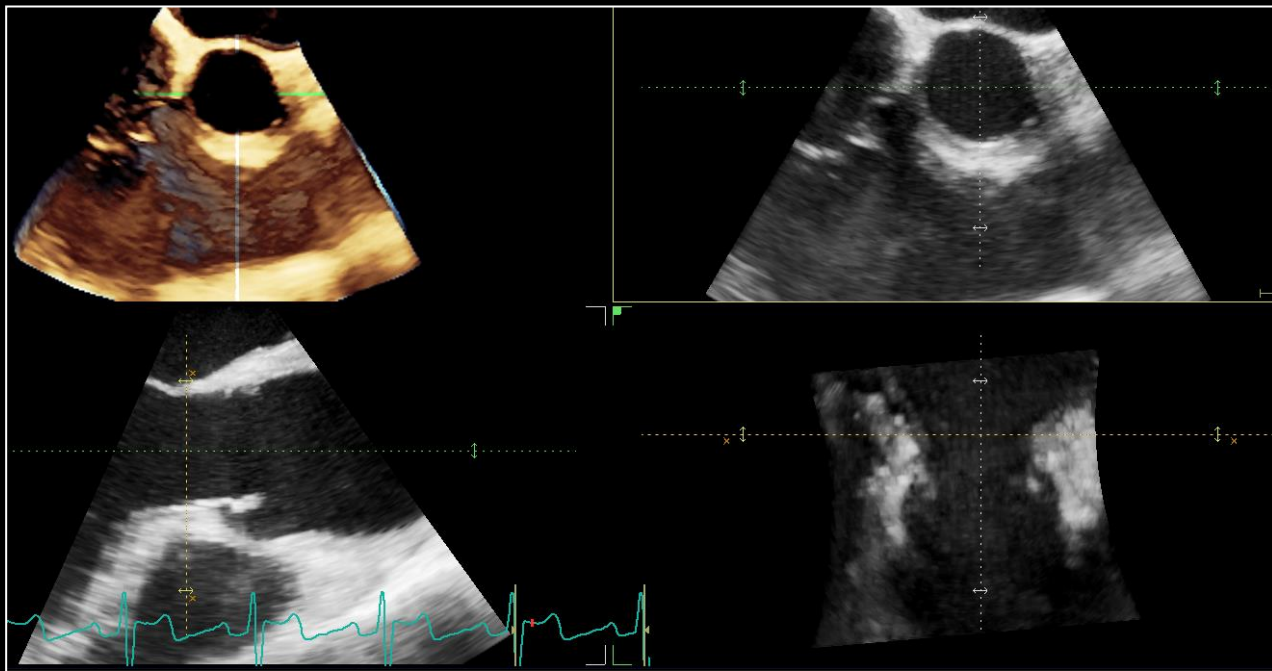


# Visualization in fixed planes:

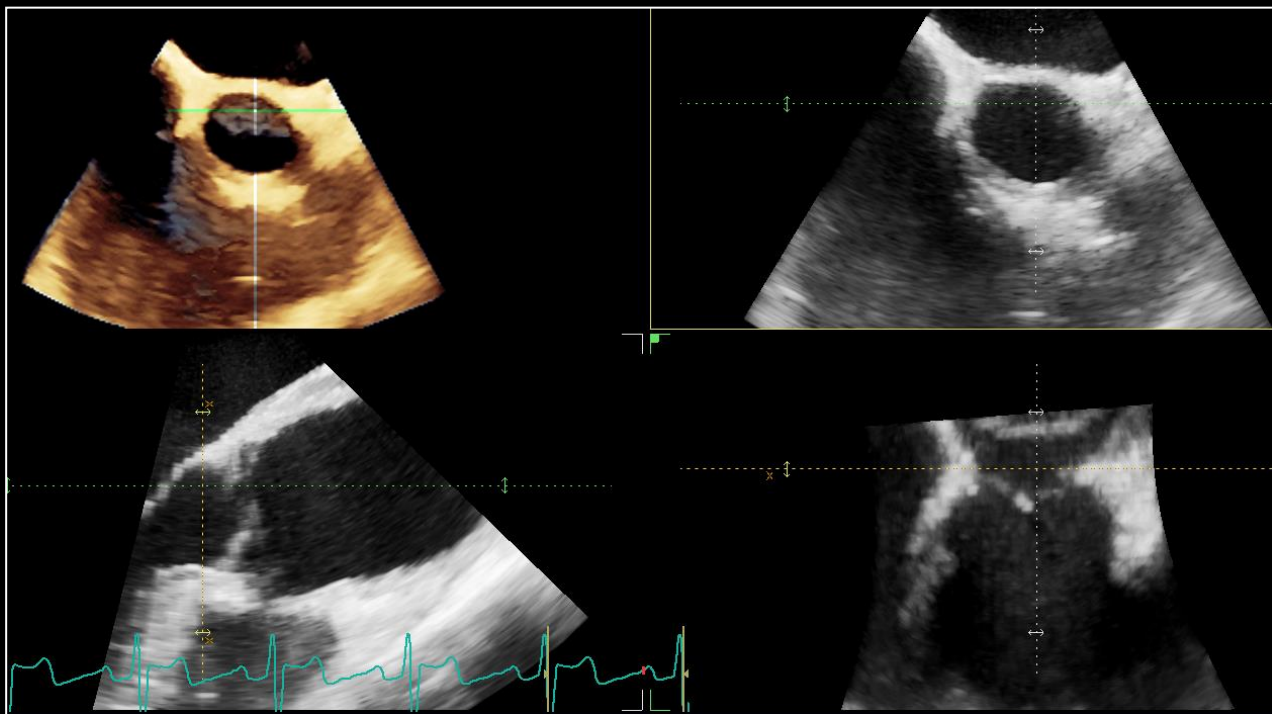
- above the valve



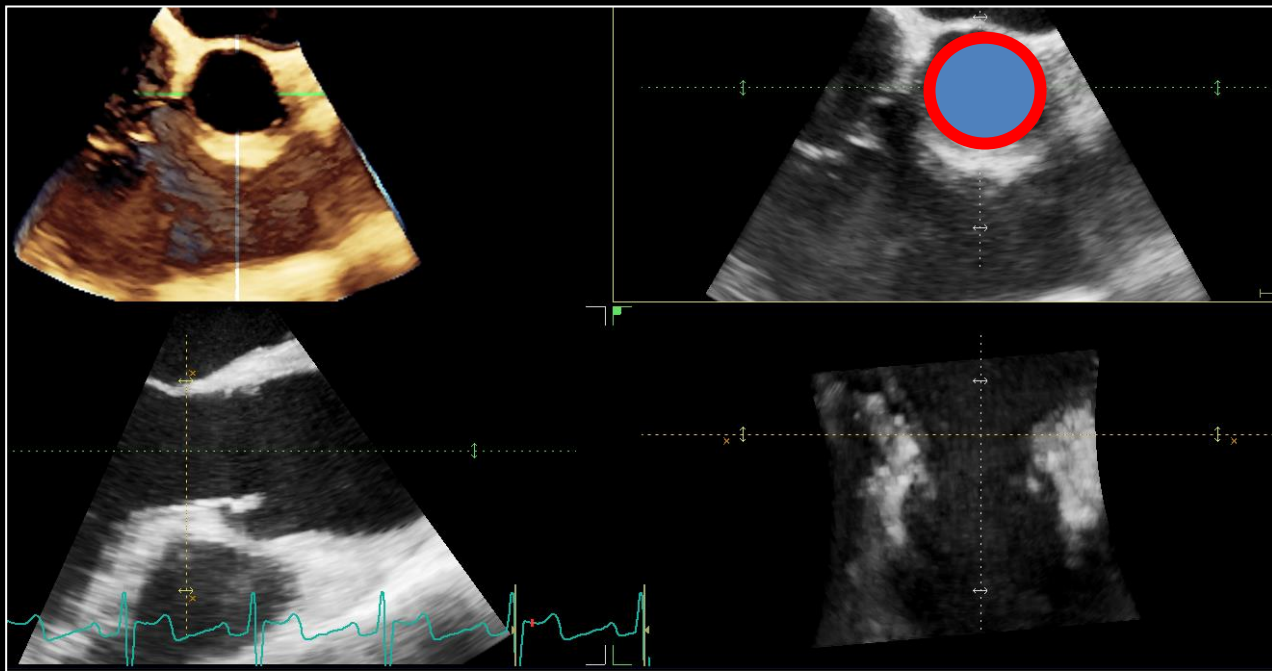




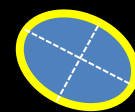
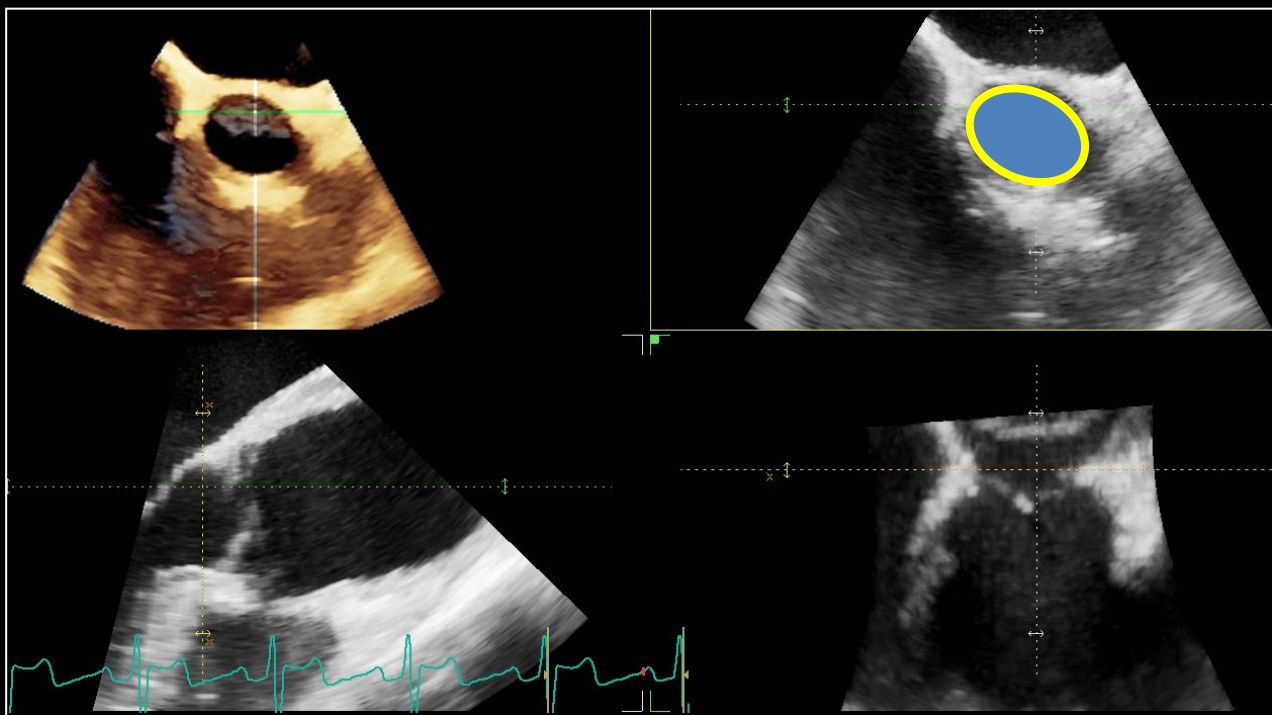
Systole



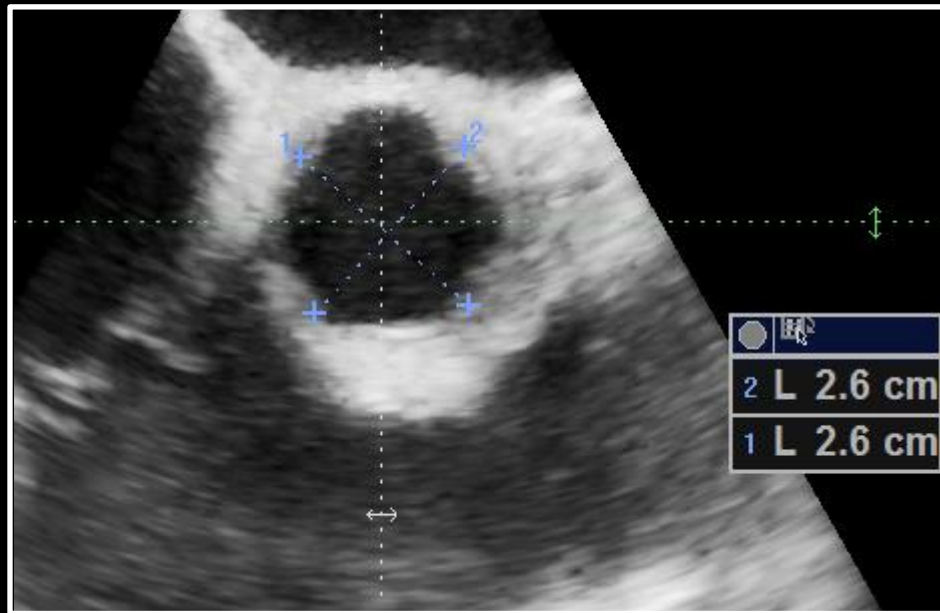
Diastole



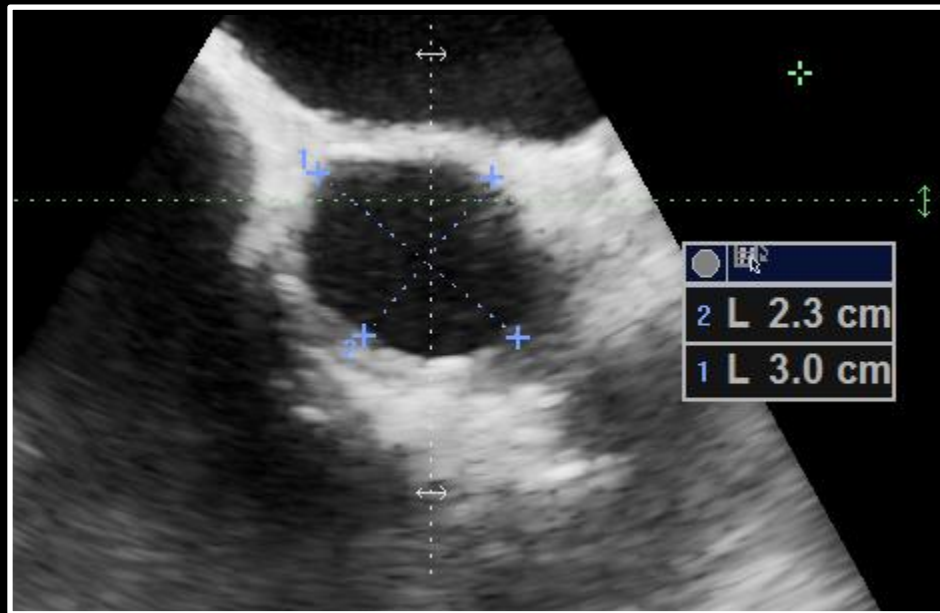
Systole



Diastole

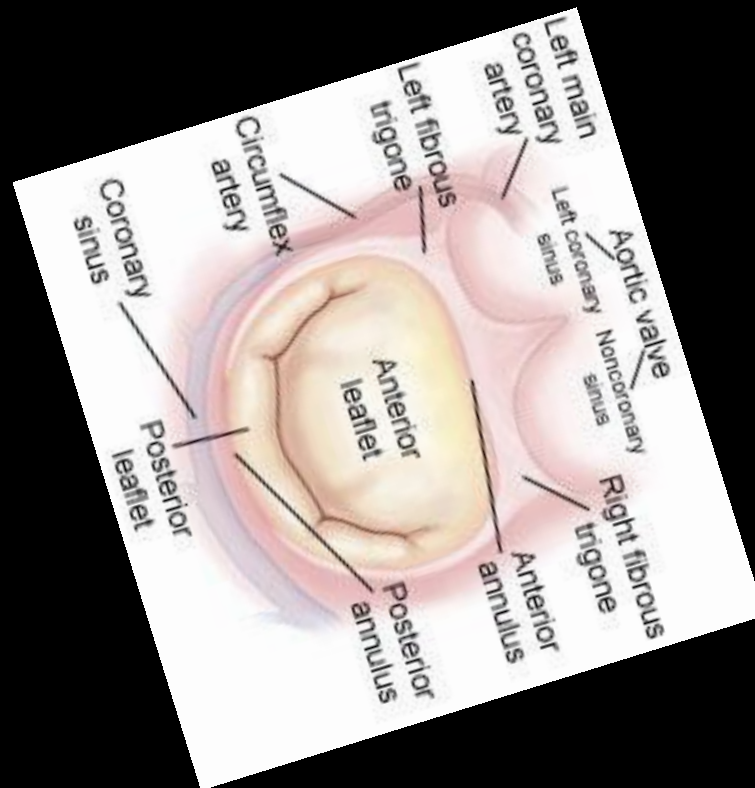


Systole



Diastole

# Aortico-mitral coupling throughout the cardiac cycle



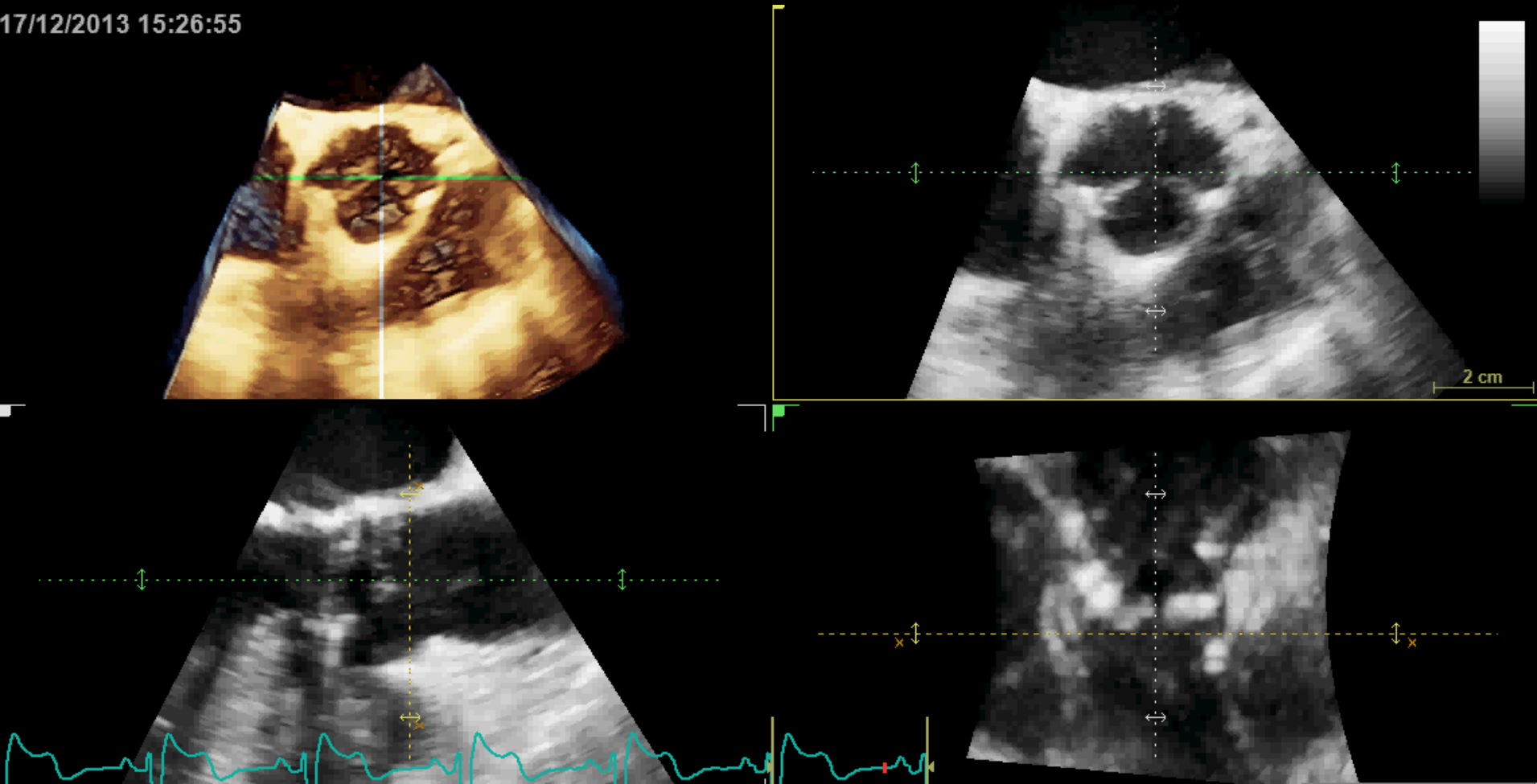
whole cycle



# Measuring the aortic root from 3D TEE

W. M.; 86 J., severe AS, planning transfemoral TAVI

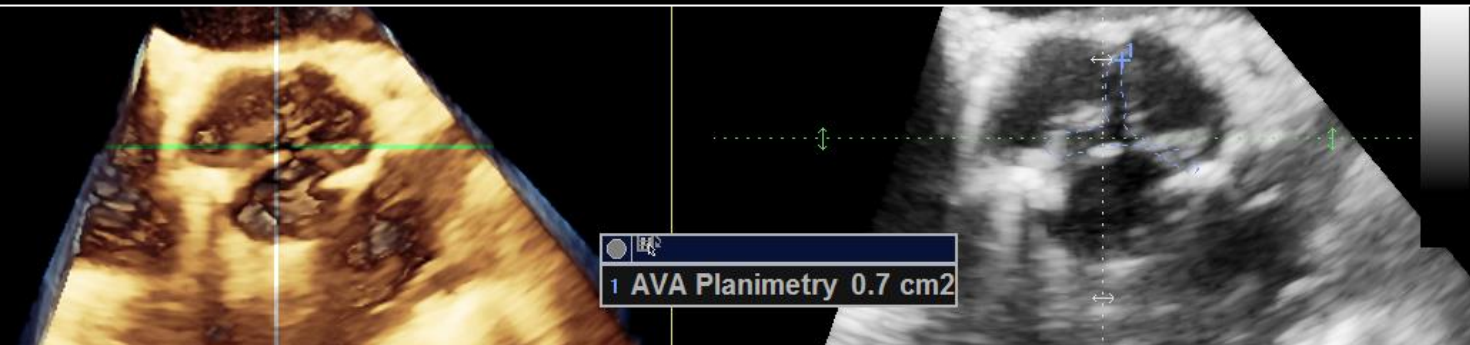
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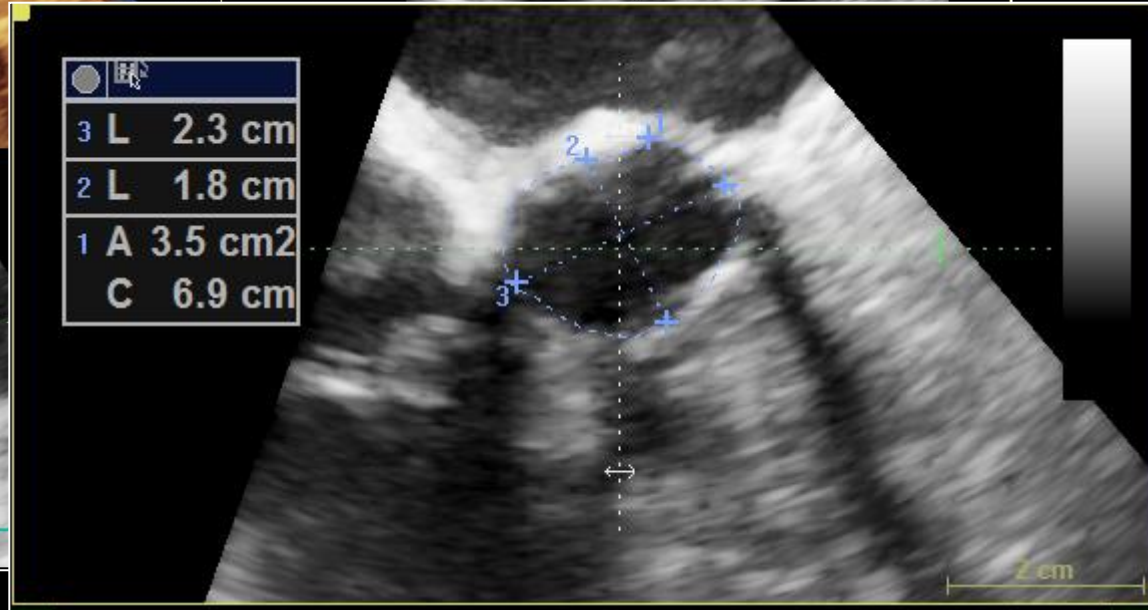
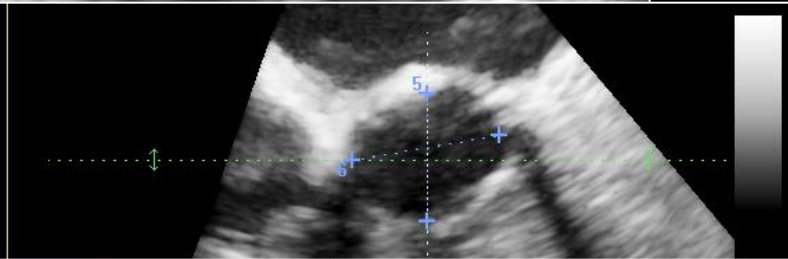
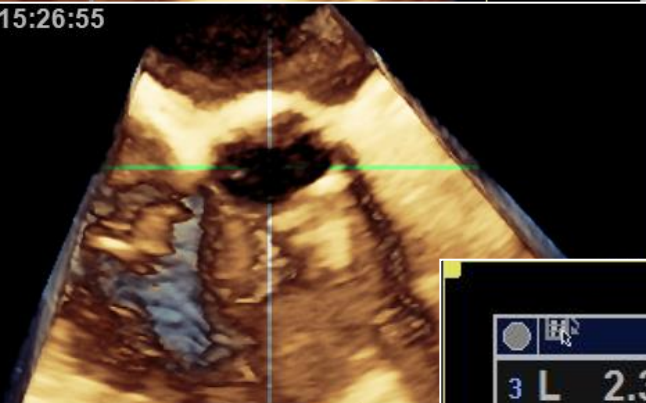
Übersicht durch zentrales Scannen, systolisches Bild:  
Planimetrie, ausmessen von vier Diamtern

# Vermessung der Aortenwurzel aus dem 3D TEE

W. M.; 86 J., hochgradige symptomatische AS, transfemorale TAVI geplant

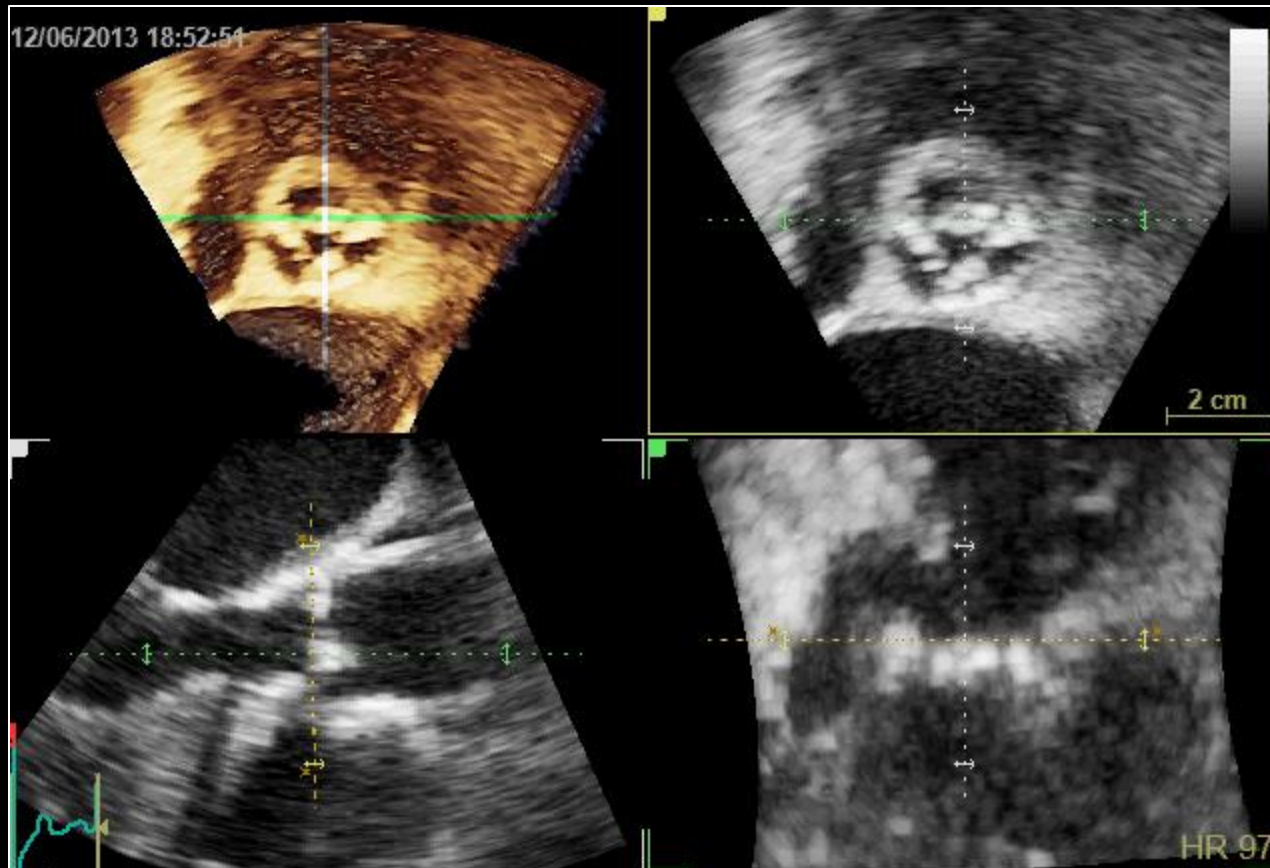


7/12/2013 15:26:55



# Vermessung der Aortenwurzel aus dem 3D TEE

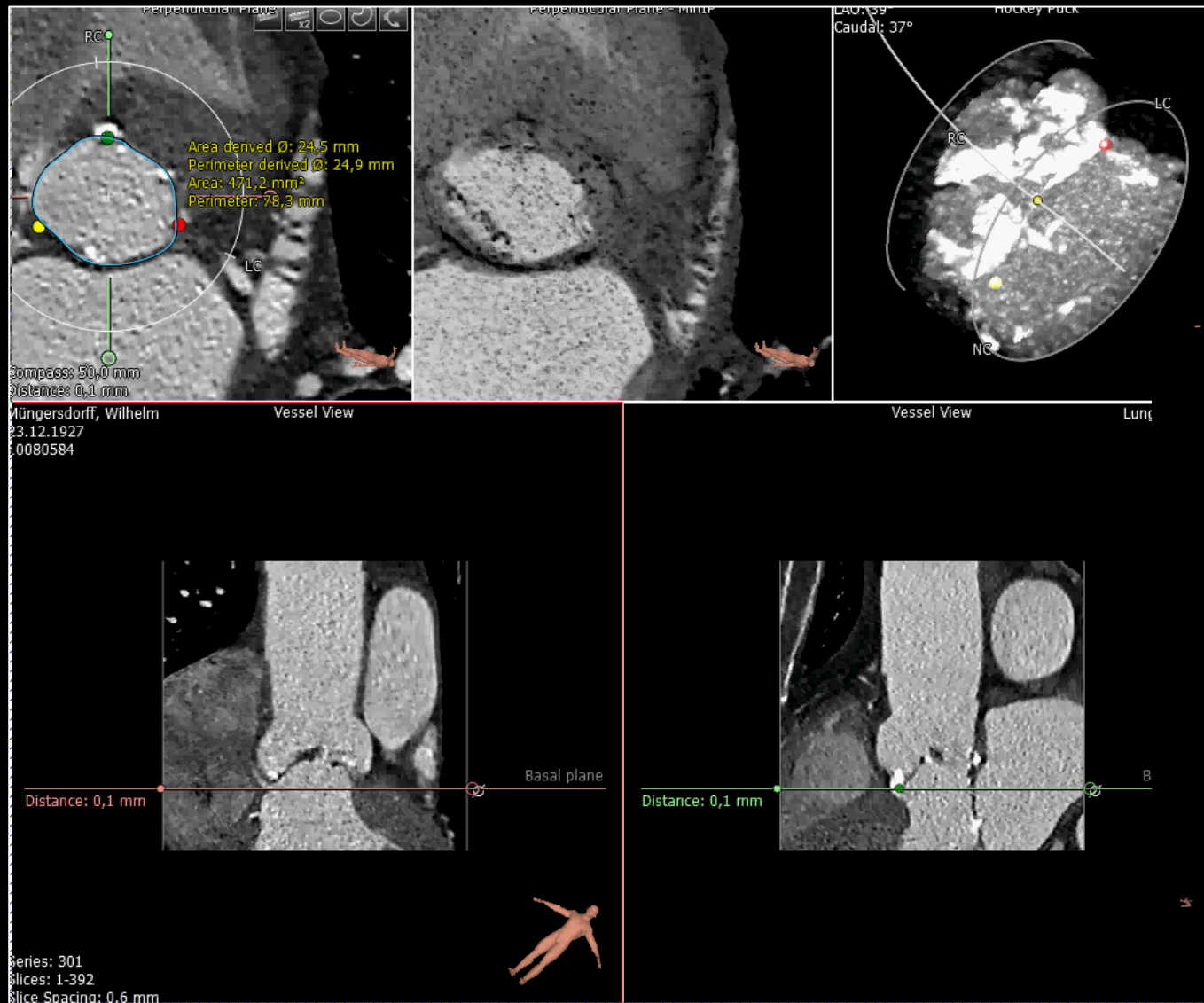
W. M.; 86 J., hochgradige symptomatische AS, transfemorale TAVI geplant



Bildorientierung „ausnahmsweise“ am CT orientiert,  
Ansicht vom LVOT und anterior vorne

# Vermessung der Aortenwurzel aus dem 3D TEE

W. M.; 86 J., hochgradige symptomatische AS, transfemorale TAVI geplant

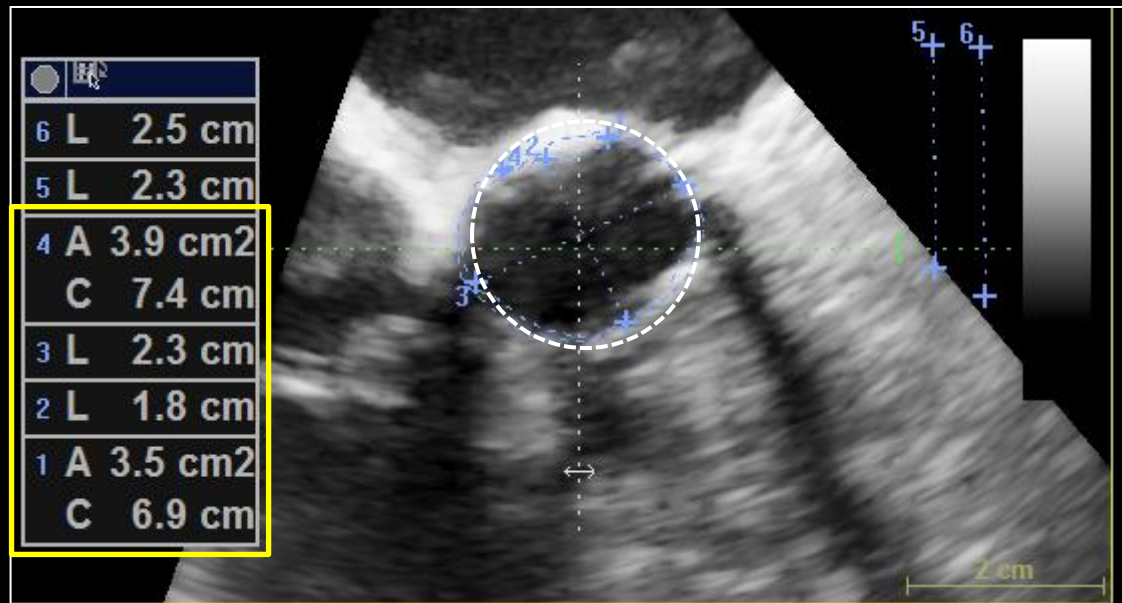
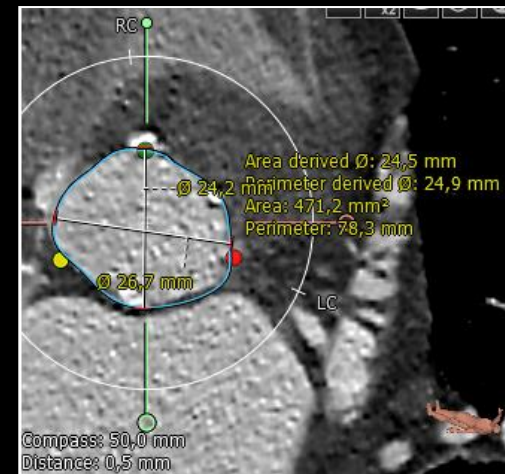
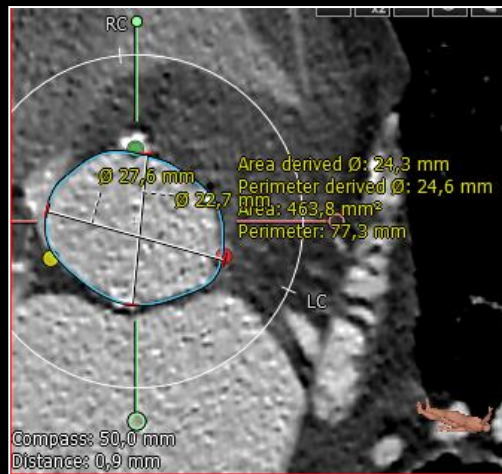


Halbautomatisierte CT-Vermessung der Aortenwurzel 3mensio®

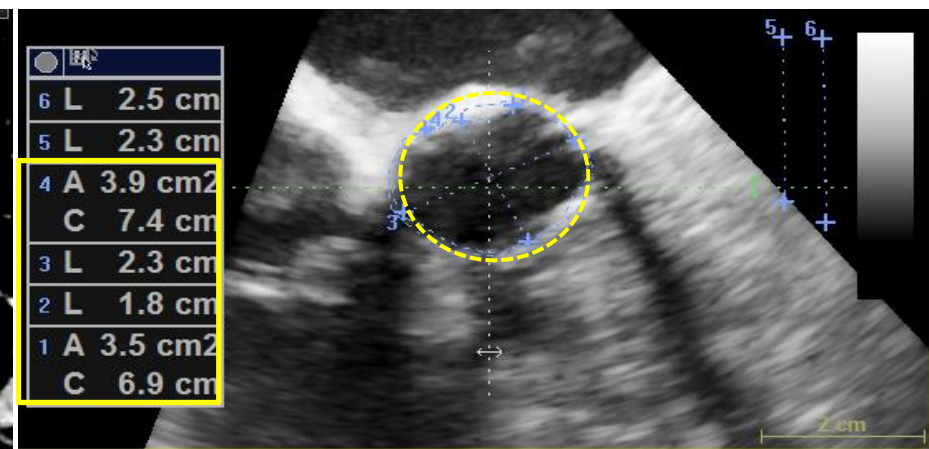
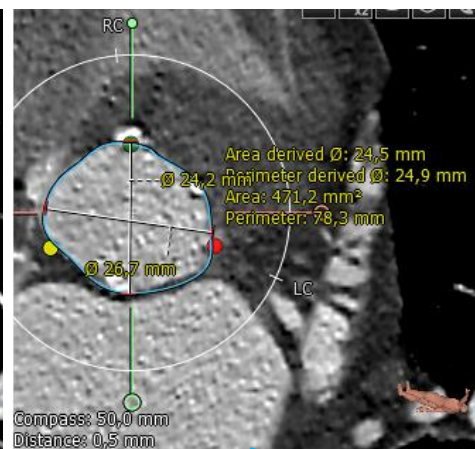
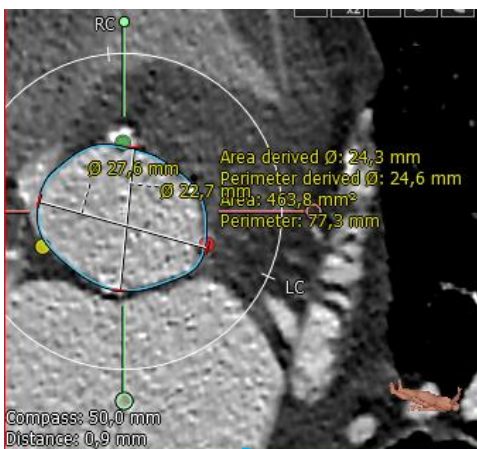


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W. M.; 86 J., hochgradige symptomatische AS, transfemorale TAVI geplant



Halbautomatisierte CT-Vermessung der Aortenwurzel 3mensio®



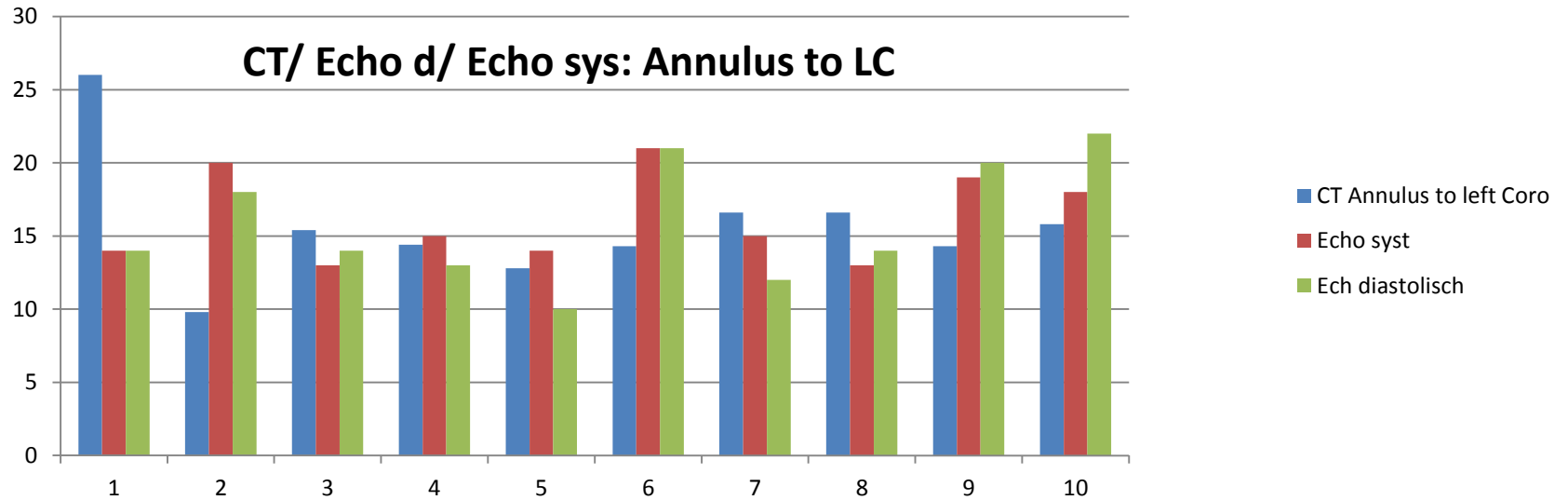
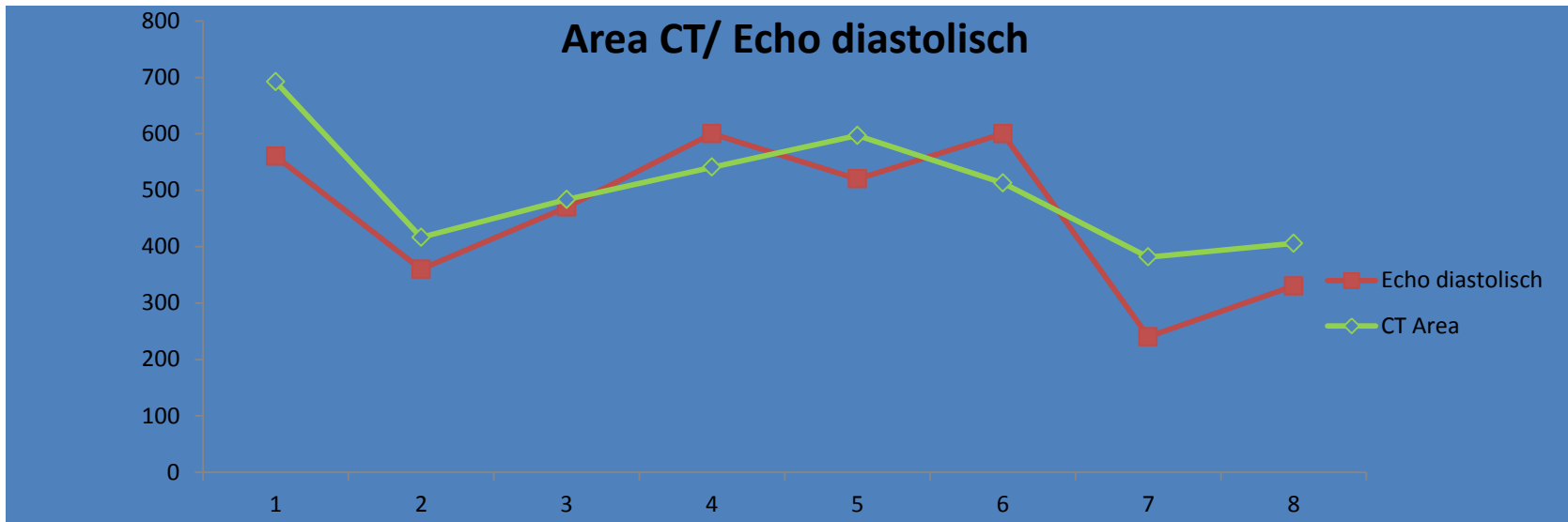
6	L	2.5 cm
5	L	2.3 cm
4	A	3.9 cm <sup>2</sup>
	C	7.4 cm
3	L	2.3 cm
2	L	1.8 cm
1	A	3.5 cm <sup>2</sup>
	C	6.9 cm

	CT 3mensio (1)	CT 3mensio (2)	3D TEE (1)	3D TEE (2)
area virtual ring	463,8	471,2	350,0	390,0
circumference virtual ring	77,3	78,3	69,0	74,0
D <sub>area</sub>	24,3	24,5	21,1	22,3
D <sub>circ</sub>	24,6	24,9	22,0	23,6
D <sub>max</sub>	26,1	26,6	22	23,0
D <sub>min</sub>	18,8	18,6	19	19,0
D <sub>long axis</sub>			20	21,0
D <sub>frontal plane</sub>			21	21,0

circle area =  $\pi \times (D/2)^2$   
 $D_{area} = 2 \times \sqrt{\text{circle area} / \pi}$

circle circumference =  $D \times \pi$   
 $D_{circ} = \text{circle circumference} / \pi$

# Vermessung der Aortenwurzel: Vergleich zwischen CT und 3D-TEE - Vorhersehbarkeit paravalvulärer Lecks (?)





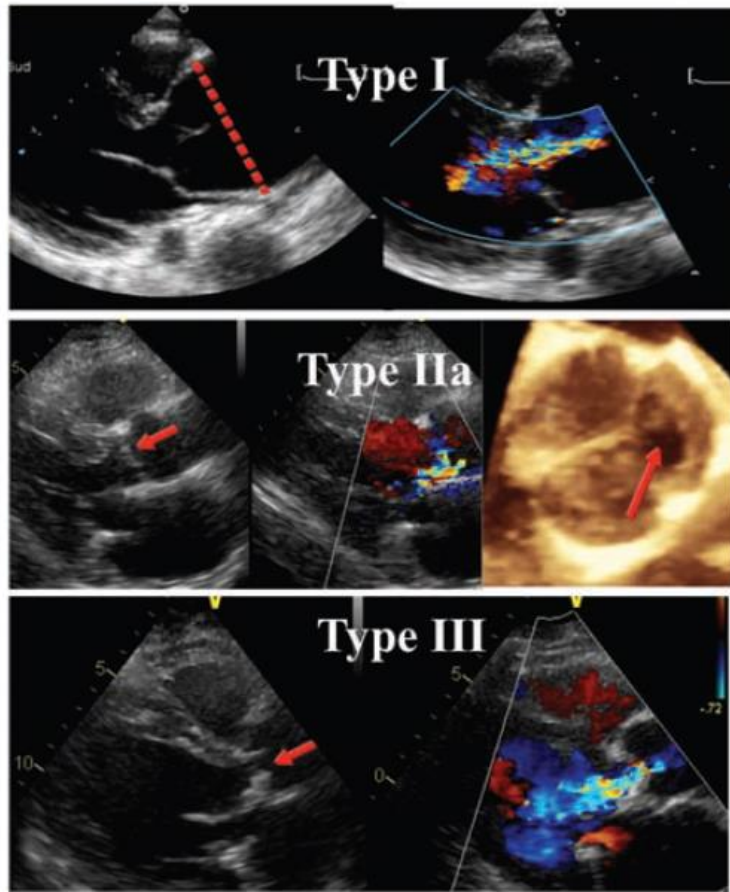
European Heart Journal – Cardiovascular Imaging (2013) **14**, 611–644  
doi:10.1093/ehjci/jet105

**RECOMMENDATIONS**

# **Recommendations for the echocardiographic assessment of native valvular regurgitation: an executive summary from the European Association of Cardiovascular Imaging**

**Patrizio Lancellotti<sup>1\*</sup>, Christophe Tribouilloy<sup>2</sup>, Andreas Hagendorff<sup>3</sup>, Bogdan A. Popescu<sup>4</sup>, Thor Edvardsen<sup>5</sup>, Luc A. Pierard<sup>1</sup>, Luigi Badano<sup>6</sup>, and Jose L. Zamorano<sup>7</sup>, On behalf of the Scientific Document Committee of the European Association of Cardiovascular Imaging: Thor Edvardsen, Oliver Bruder, Bernard Cosyns, Erwan Donal, Raluca Dulgheru, Maurizio Galderisi, Patrizio Lancellotti, Denisa Muraru, Koen Nieman, Rosa Sicari, Document reviewers: Erwan Donal, Kristina Haugaa, Giovanni La Canna, Julien Magne, Edyta Plonska**





**Figure 2** Mechanisms of AR according to the Carpentier's functional classification. Type: aortic annulus dilatation; Type IIa: prolapse of the left coronary cusp (arrow); Type III: rheumatic aortic valve disease with restricted cusp motion.

**Table 3** Functional classification of AR lesions

Dysfunction	Echo findings
Type I: enlargement of the aortic root with normal cusps	Dilatation of any components of the aortic root (aortic annulus, sinuses of valsalva, sinotubular junction)
Type IIa: cusp prolapse with eccentric AR jet	
Cusp flail	Complete eversion of a cusp into the LVOT in long-axis views
Partial cusp prolapse	Distal part of a cusp prolapsing into the LVOT (clear bending of the cusp body on long-axis views and the presence of a small circular structure near the cusp free edge on short-axis views)
Whole cusp prolapse	Free edge of a cusp overriding the plane of aortic annulus with billowing of the entire cusp body into the LVOT (presence of a large circular or oval structure immediately beneath the valve on short-axis views)
Type IIb: free edge fenestration with eccentric AR jet	Presence of an eccentric AR jet without definite evidence of cusp prolapse
Type III: poor cusps quality or quantity	Thickened and rigid valves with reduced motion Tissue destruction (endocarditis) Large calcification spots/extensive calcifications of all cusps interfering with cusp motion

## **Valve sparing root replacement: the remodeling technique with external ring annuloplasty**

Emmanuel Lansac<sup>1</sup>, Isabelle Di Centa<sup>2</sup>, Jan Vojacek<sup>3</sup>, Jan Nijs<sup>4</sup>, Jaroslav Hlubocky<sup>5</sup>, Gianclaudio Mecozzi<sup>6</sup>, Mathieu Debauchez<sup>7</sup>

## Phenotypes of the ascending aorta



Aortic root aneurysm  
Valsalva  $\geq 45$  mm



Supra-coronary aneurysm  
Valsalva  $< 40$  mm  
Supracoronary Aorta  $> 45$



Isolated AI  
Valsalva  $< 40$  mm  
Supracoronary Aorta  $< 40$

## Standardized and physiological approach to aortic valve repair

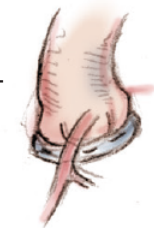
### Root reconstruction



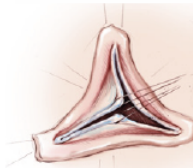
Remodeling  
+ sub-valvular  
annuloplasty



Supra-coronary  
graft + sub-valvular  
annuloplasty  
(annulus  $\geq 25$  mm)



Sub-valvular  
annuloplasty  
(annulus  $\geq 25$  mm)



Alignment of cusp free edges



Resuspension of cusp effective height

+



Subvalvular external aortic annuloplasty



**Figure 7** Standardized and physiological approach to aortic valve repair according to each phenotype of ascending aorta

# Practical approach for decision making in AR and diseases of the ascending aorta

D. Aicher, H.J. Schaefers

**Isolated aortic valve reconstruction** (a: plication; b: triangular resection; c: pericardial path) – normal sinus diameter (<40mm) and normal sinutubular junction (<33mm)

**Supracommissural replacement of ascending aorta** – dilated sinutubular junction (>33mm) and normal dimension of sinus (<40mm)

**Aortic root remodeling** (Yacoub) – dilated sinus (>40mm) and dilated sinutubular junction (>33mm)

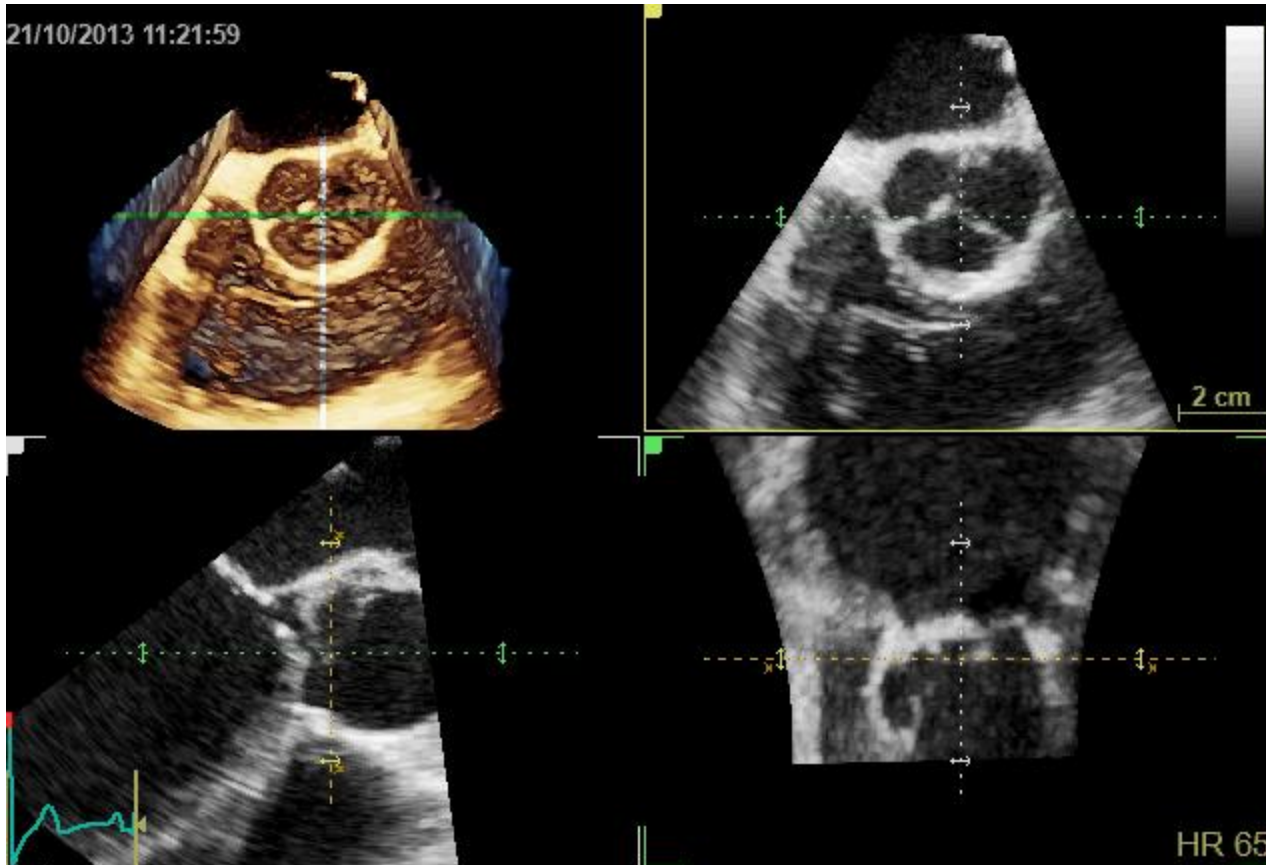
**Dilated basal ring** (>25mm) additional annuloplasty in all reconstruction modalities

**Aim of each reconstruction: normalisation of dimensions of Aorta adequate konfiguration of cusps (effective height 10 mm).**



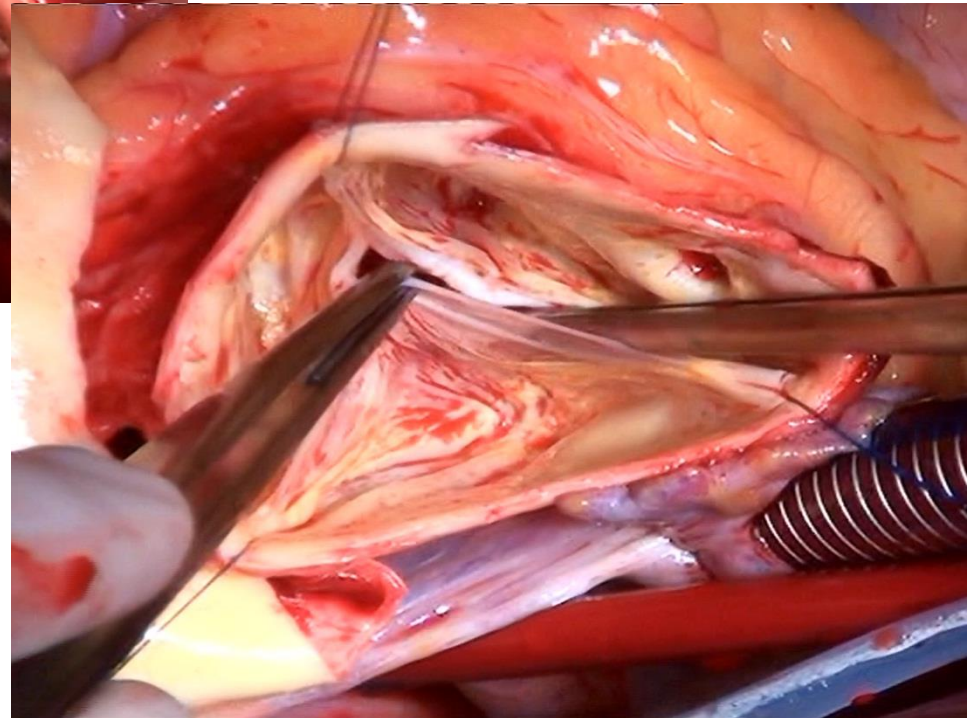
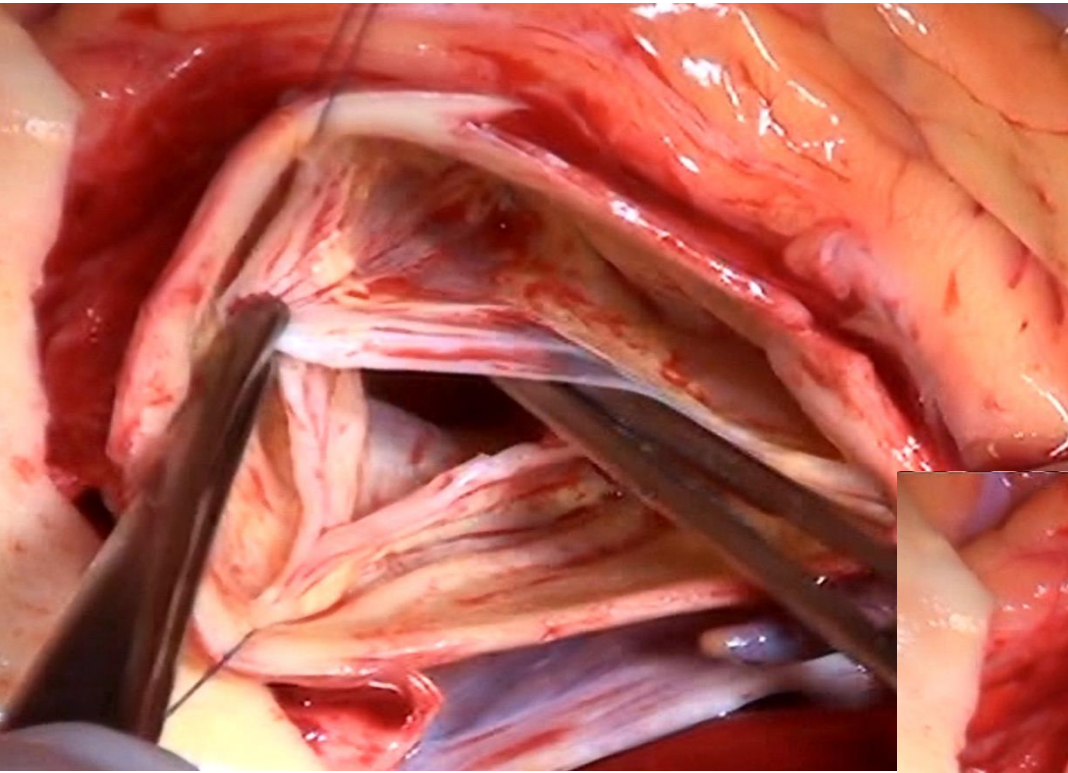


# Echocardiographic **predictors of successful AV repair**



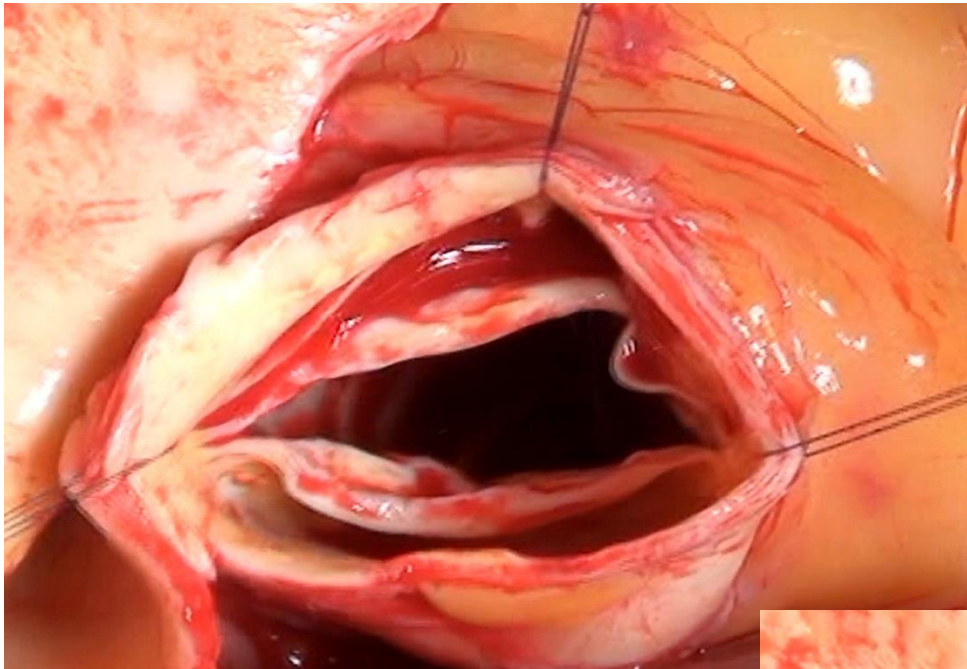
56 y, m, asymptomatic AR III

## Surgical examination of the valve

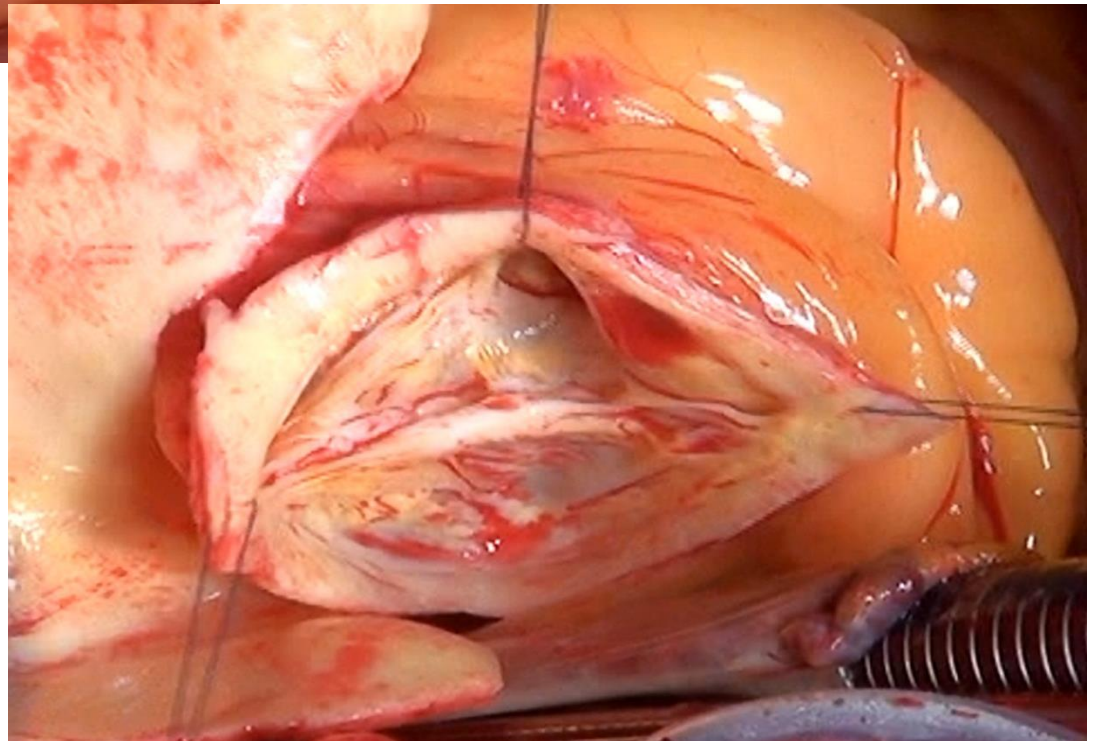


Reconstruction of the Aortic Valve  
and Root, Homburg  
2013 May 15th/16th/17th Case 2  
Prof. Schaefers





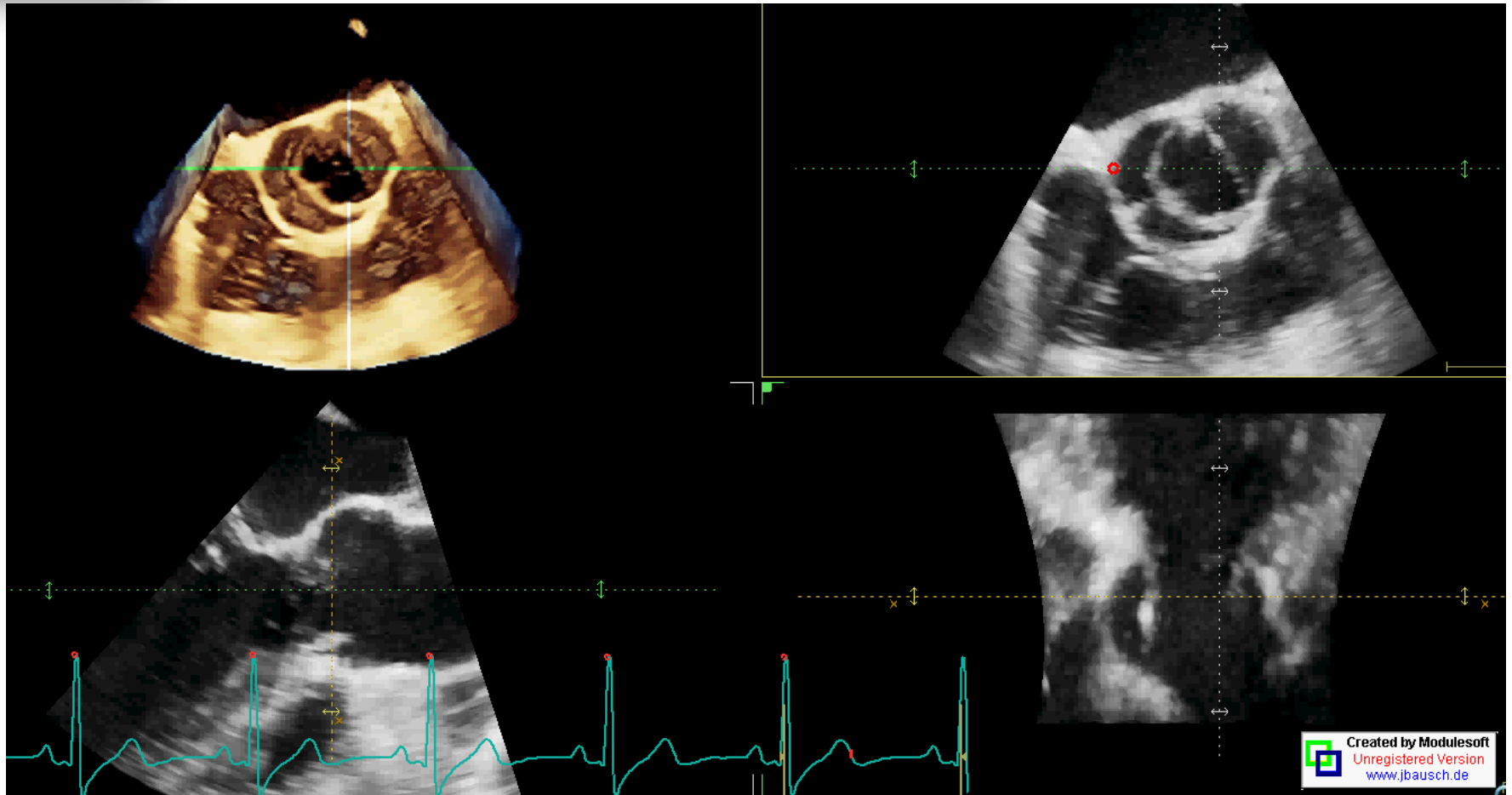
Fused cusp in bicuspid aortic valve





# Echocardiographic **predictors of successful AV repair**

Localization and characterization of aortic valve pathology by 3D TEE



56 y, m, asymptomatic AR III



## Aortic root and cusp configuration determine aortic valve function<sup>☆</sup>

Benjamin Oliver Bierbach<sup>a</sup>, Diana Aicher<sup>a</sup>, Omar Abu Issa<sup>a</sup>, Hagen Bomberg<sup>a</sup>,  
Stefan Gräber<sup>b</sup>, Petra Glombitza<sup>a</sup>, Hans-Joachim Schäfers<sup>a,\*</sup>

<sup>a</sup>Department of Thoracic and Cardiovascular Surgery, University Hospitals of Saarland, Kirrbergerstrasse 1, 66421 Homburg/Saar, Germany

<sup>b</sup>Institute for Medical Biometry, Epidemiology and Informatics, University Hospitals of Saarland, Homburg/Saar, Germany

Received 30 September 2009; received in revised form 19 January 2010; accepted 21 January 2010; Available online 12 March 2010

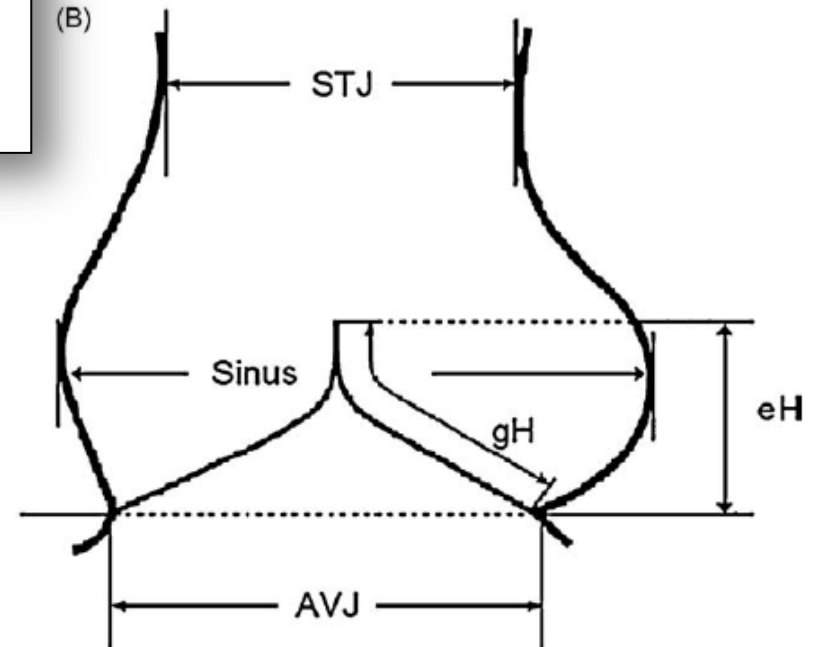


Fig. 1. Aortic root dimensions at different levels and effective height measured by transthoracic echocardiography in the long parasternal axis (A) and a schematic drawing (B). STJ: sinutubular junction; Sinus: maximum sinus diameter, gH: geometric height; eH: effective height; AVJ: aortoventricular junction.

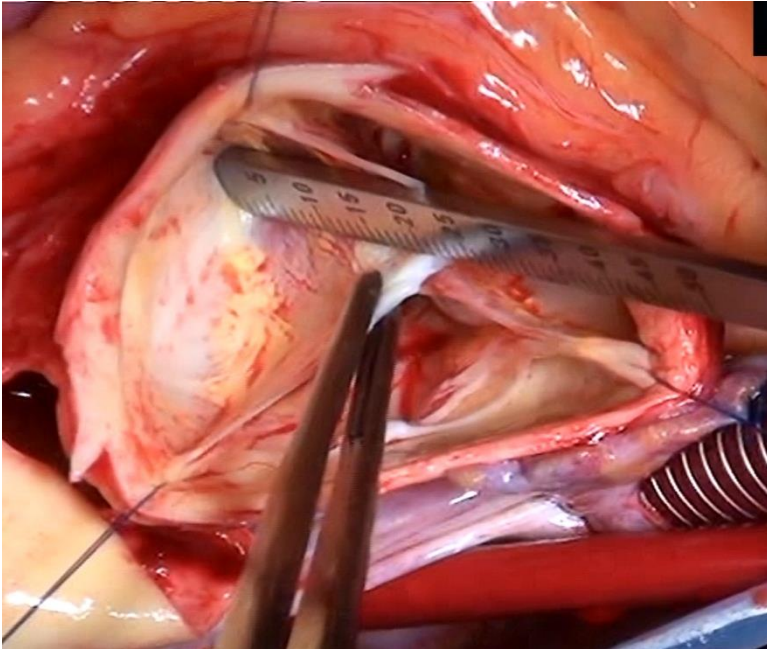
**Conclusions:** Parameters of aortic root dimensions follow a seemingly constant pattern in humans of different sizes. Effective height has a constant relationship to root dimensions and body size. In AVR, normalisation of eH leads to a high probability of normal or near-normal aortic valve function.



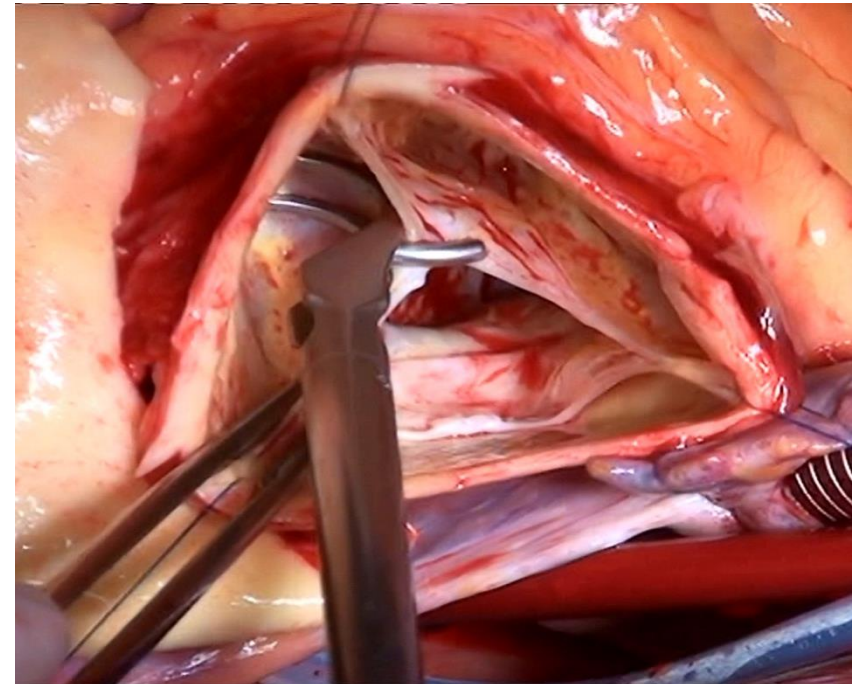
# Echocardiographic **predictors of successful AV repair**

Intraoperative surgical measurements

geometric height left



effective height left

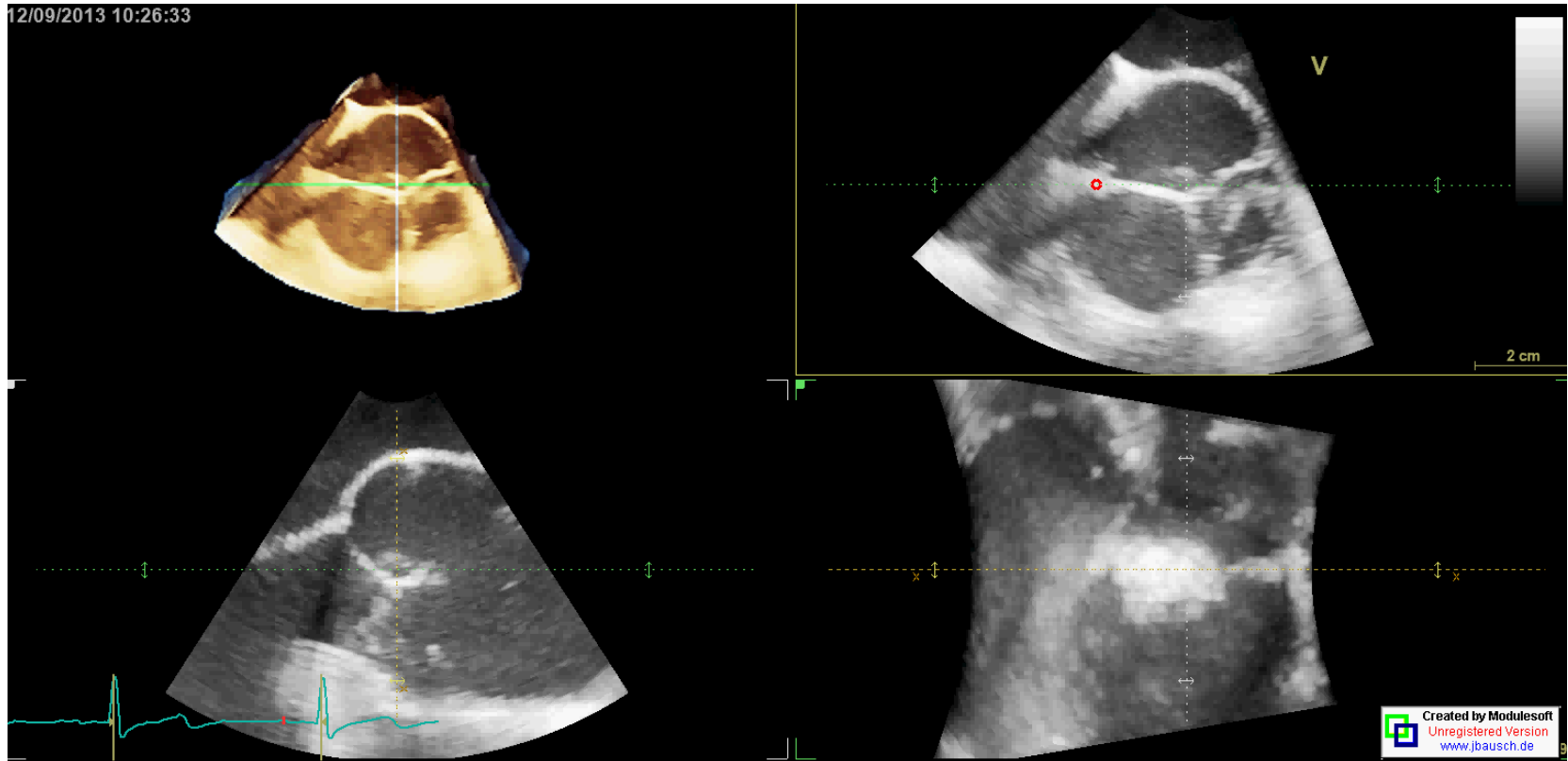


Reconstruction of the Aortic Valve  
and Root, Homburg  
2013 May 15th/16th/17th Case 2  
Prof. Schaefers



# Echocardiographic **predictors of successful AV repair**

Measurement of the effective height for each aortic valve cusp by 3D TEE

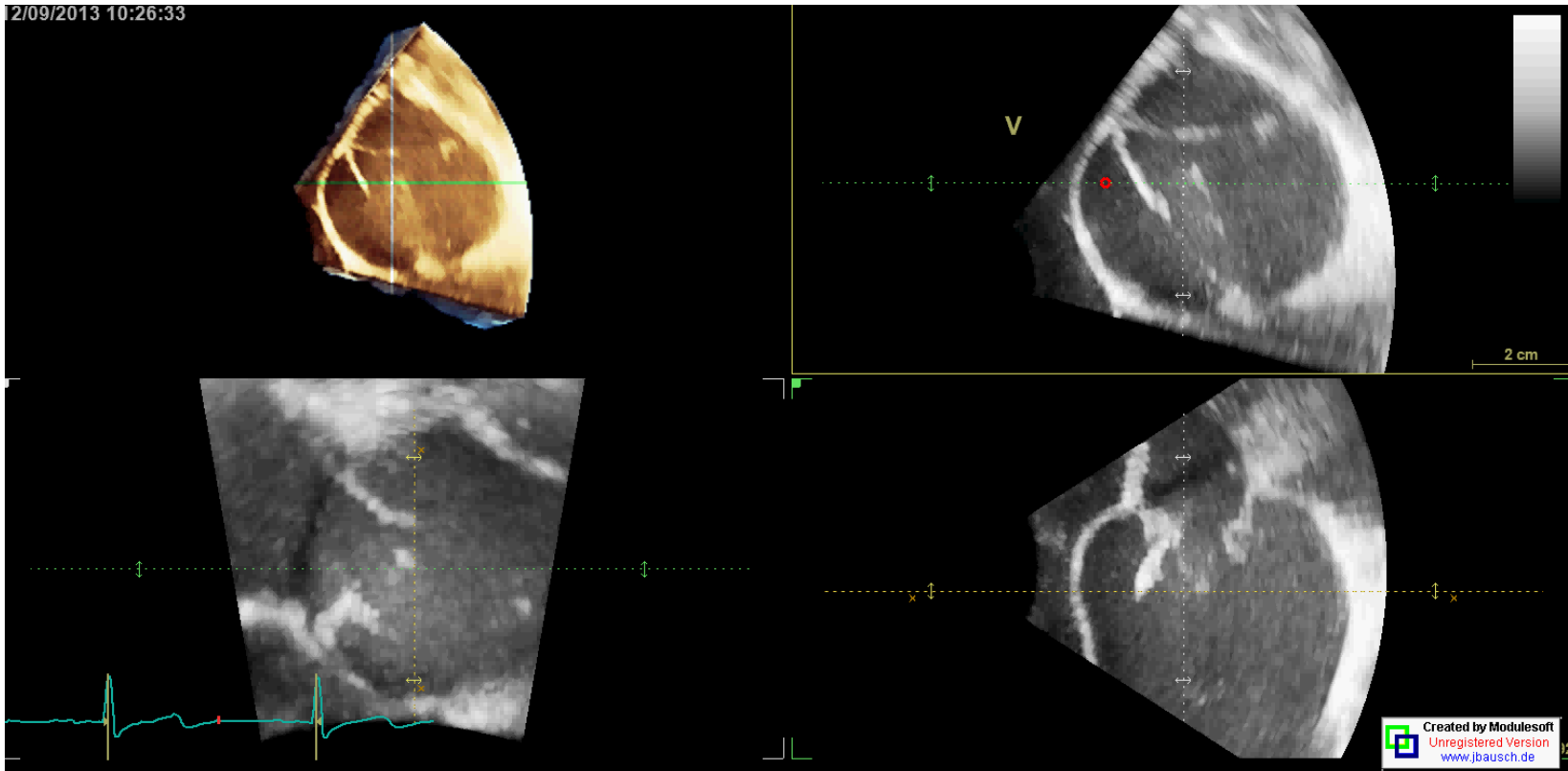


Reconstruction of the Aortic Valve  
and Root, Homburg  
2013 May 15th/16th/17th Case 3  
Prof. Schaeffers



# Echocardiographic **predictors of successful AV repair**

Measurement of the effective height for each aortic valve cusp by 3D TEE



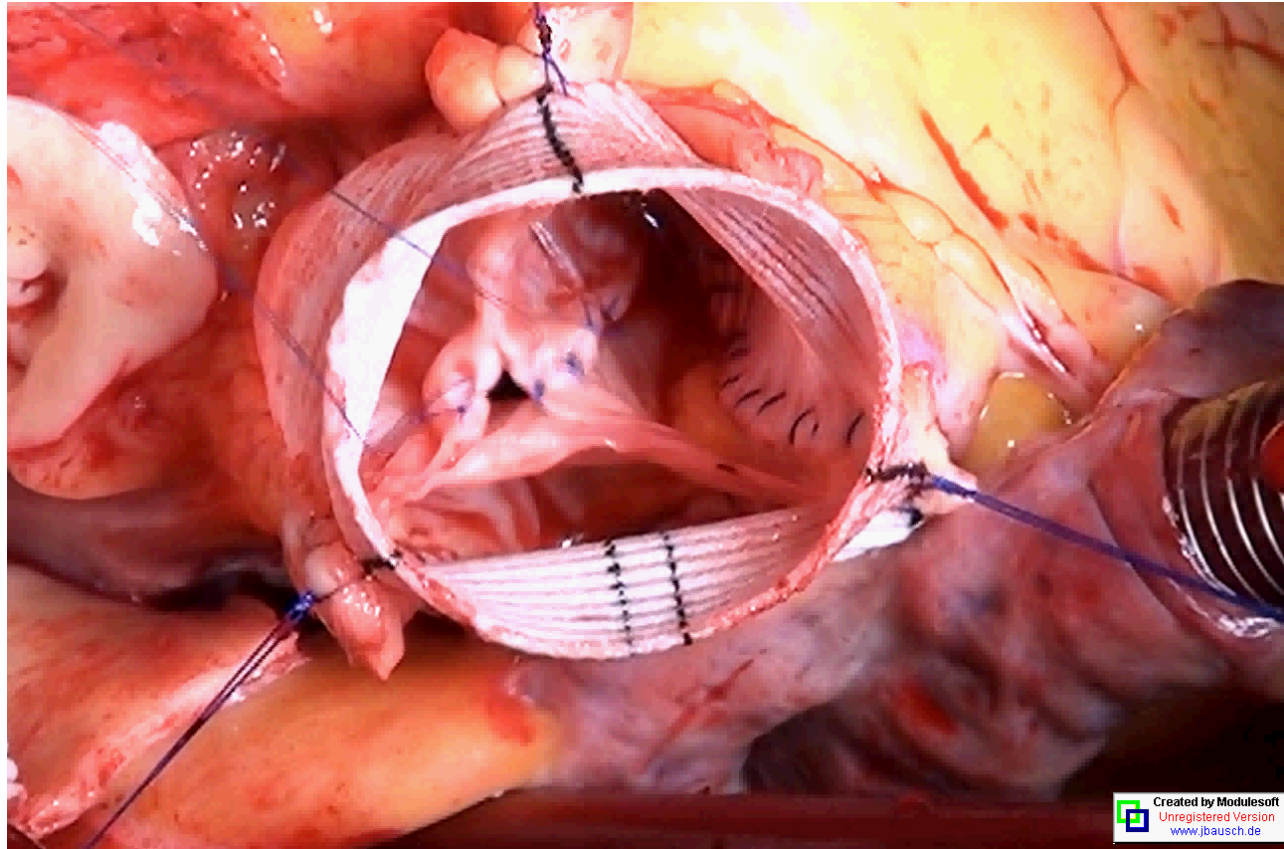
Reconstruction of the Aortic Valve  
and Root, Homburg  
2013 May 15th/16th/17th Case 3  
Prof. Schaefers

Left coronary cusp measurements not possible in 2D echo





## Echocardiographic **predictors of successful AV repair**

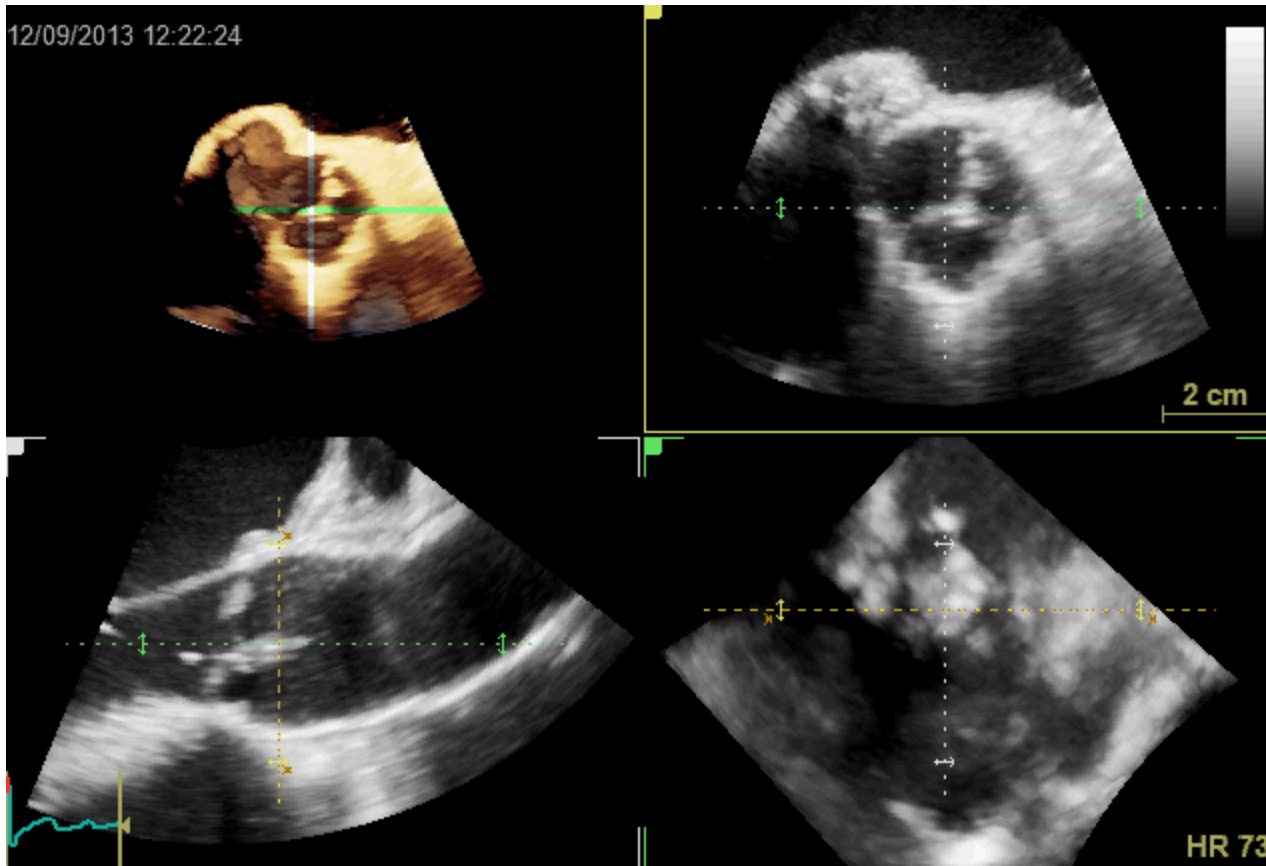


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# Echocardiographic **predictors of successful AV repair**

Postoperative control after repair of aortic valve

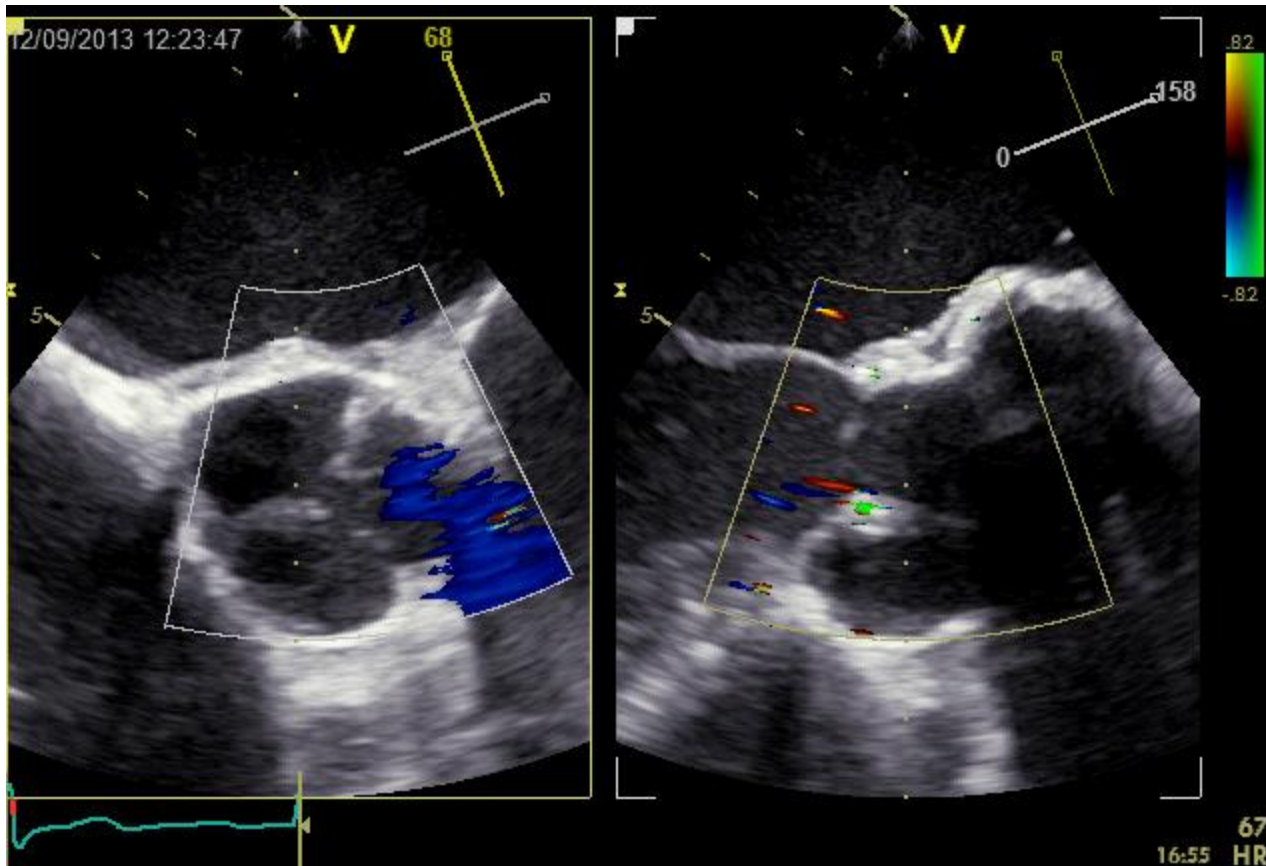


Reconstruction of the Aortic Valve  
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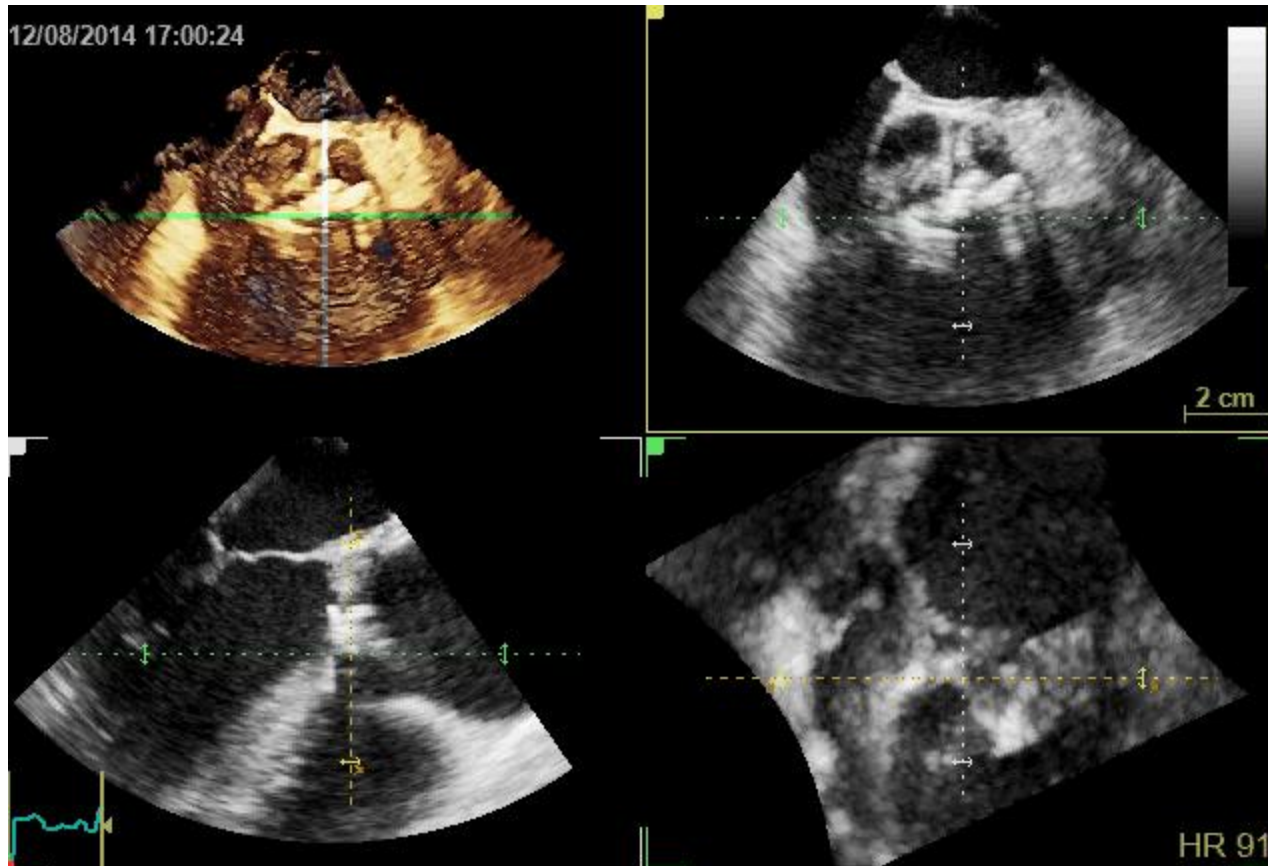
# Echocardiographic **predictors of successful AV repair**

Postoperative control after repair of aortic valve



Reconstruction of the Aortic Valve  
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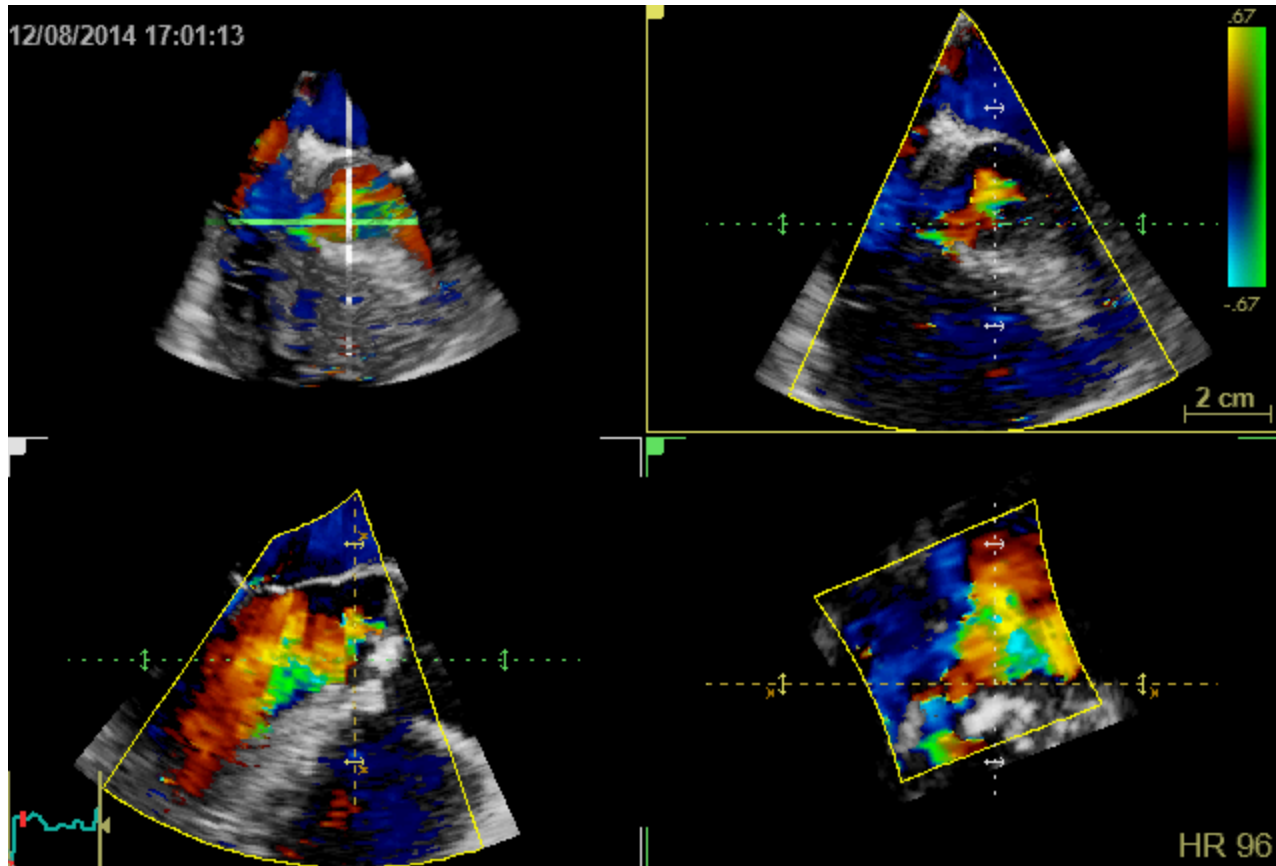
S. R., 60 y, m; AI III/IV, NYHA I - II



Bicuspid AV, calcified commissure (raphe) between right and left coronary cusp

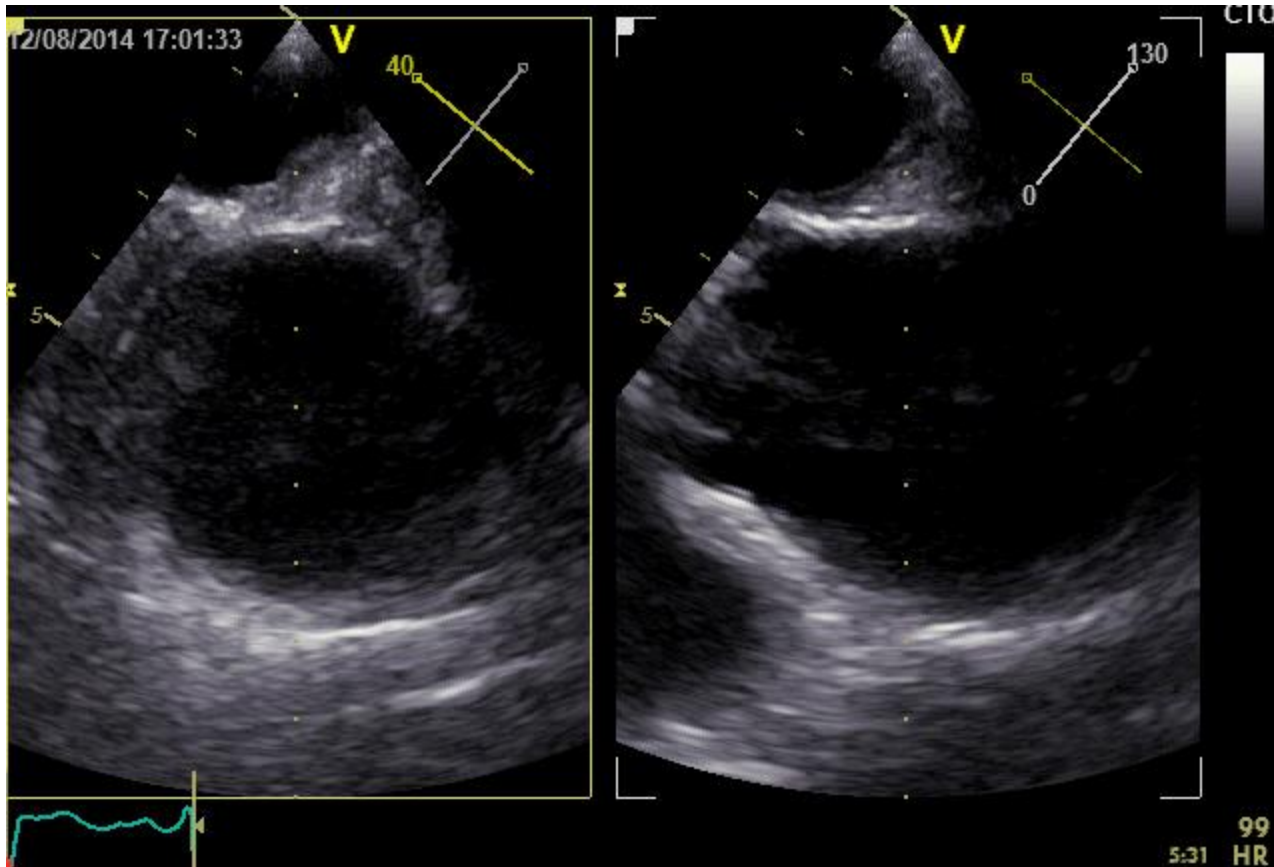


S. R., 60 y, m; AI III/IV, NYHA I - II



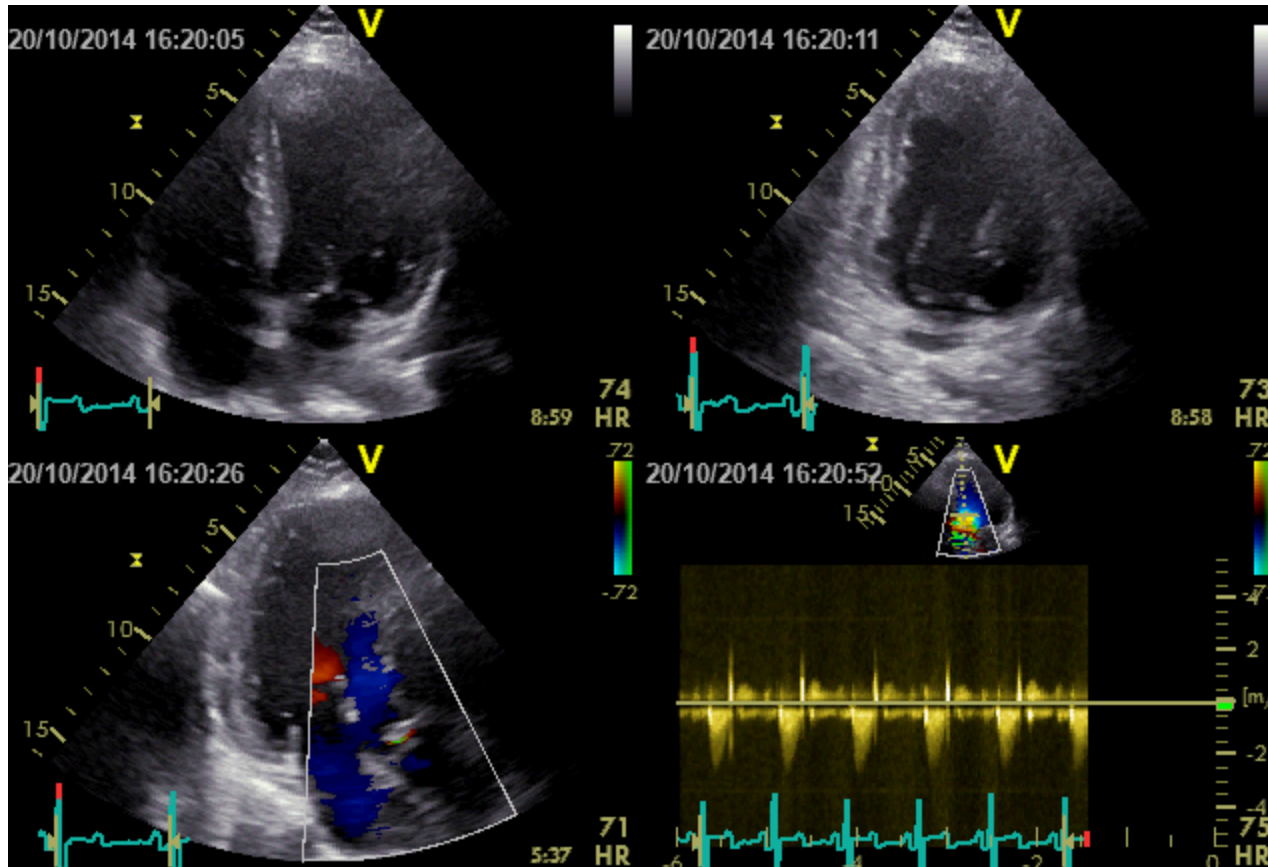
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S. R., 60 y, m; AI III/IV, NYHA I - II



Bicuspid AV, calcified commissure (raphe) between right and left coronary cusp

**Postoperative no leak no stenosis**

*la pratica dev' essere edificata sopra la buona teorica*  
*(Practice must always be founded on sound theory)*  
*Leonardo Da Vinci*

## Conclusion:

- Standard reference values of the aortic root and the ascending aorta have to be referred either to systolic or diastolic phase – large discrepancies in normal values
- Functional anatomy and pathology can precisely be analyzed pre- (and post) operatively – **3D TEE is mandatory**

Reconst  
A practic

■ Wednesday, May 20<sup>th</sup> to Friday, May 22<sup>nd</sup>, 2015

Location  
University Hospital of Saarland  
Homburg/Saar, Germany

Chairman  
Prof. Hans-Joachim Schäfers



UKS  
Universitätsklinikum  
des Saarlandes